WELDING

The Journal of the American Welding Society

Whether it's Surfacing Runner Blades for a Hydroelectric Plant or Fabricating Soup Kettles for the Food Industry, ARCOS HAS THE RIGHT ELECTRODE FOR THE JOB

There isn't space to list all the projects in which Arcos electrodes are involved. Make use of the thirteen years specialized experience of the Arcos organization for specific information on any job in which you are interested. ★ The newly issued Arcos Specification Chart, which is yours for the asking, will give you complete data on all Arcos electrodes. Use it as your buying guide.

ARCOS CORPORATION
401 NORTH BROAD ST., PHILADELPHIA 8, PA.

ARMY (E) NAVY

Distributors Warehouse Stocks in the Following Cities:

Baton Rouge, La. . . . . Wm. D. Seymour Co.	Los Angeles, Calif. . . . . Victor Equipment Co.
Borger, Texas . . . . . Hart Industrial Supply Co.	Milwaukee, Wis. . . . Machinery & Welder Corp.
Boston, Mass. . . . . H. Boker & Co., Inc.	Moline, Ill. . . . . Machinery & Welder Corp.
Buffalo, N. Y. . . . . Root, Neal & Co.	Montreal, Canada . G. D. Peters & Co. of Canada, Ltd.
Chicago, Ill. . . . . Machinery & Welder Corp.	New Orleans, La. . . . . Wm. D. Seymour Co.
Cincinnati, Ohio . . . . . Williams & Co., Inc.	New York, N. Y. . . . . H. Boker & Co., Inc.
Cleveland, Ohio . . . . . Williams & Co., Inc.	Oklahoma City, Okla. . Hart Industrial Supply Co.
Columbus, Ohio . . . . . Williams & Co., Inc.	Pampa, Texas . . . . . Hart Industrial Supply Co.
Detroit, Michigan . . . . C. E. Phillips & Co., Inc.	Pittsburgh, Pa. . . . . Williams & Co., Inc.
Erie, Penna. . . . . Boyd Welding Co.	Portland, Ore. . . . . J. E. Haseltine & Co.
Fresno, Calif. . . . . Victor Equipment Co.	Rochester, N. Y. . . . . Welding Supply Co.
Ft. Wayne, Ind. . Wayne Welding Sup. Co., Inc.	San Diego, Calif. . . . . Victor Equipment Co.
Honolulu, Hawaii . . Hawaiian Gas Products, Ltd.	San Francisco, Calif. . . . Victor Equipment Co.
Houston, Texas . . Champion Rivet Co. of Texas	Seattle, Wash. . . . . J. E. Haseltine & Co.
Kansas City, Mo. . Welders Supply & Repair Co.	St. Louis, Mo. . . . . Machinery & Welder Corp.
Kingsport, Tenn. . . . . Slip-Not Belting Corp.	Syracuse, N. Y. . . . . Welding Supply Co.
	Wichita, Kansas . . . . . Watkins, Inc.

it's ARCOS for stainless electrodes

"QUALITY WELD METAL EASILY DEPOSITED"

Hobarts have Exceptional Arc Stability

Throughout Their Wide Welding Range

Inherent Reactance *Assures Arc Stability at every setting*

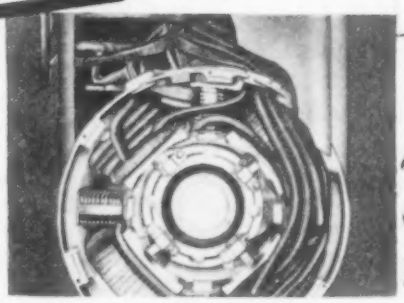
Inherent reactance, resulting from the special design of the Hobart Multi-Range Welding Generators, is responsible for the exceptional arc stability throughout their wide welding range.

No matter what the arc demands are, Hobart's exceptional arc stability will minimize spatter loss, assure good welding speed and produce good, sound joints at lower costs.

The amount of the reactance is automatically adjusted to suit the requirements of each range so that the arc will not go out when the voltage is too low and will minimize the spatter and blowing action on the bead when the current value is very high. Get a Hobart for ideal stabilization with maximum efficiency.

Go Ahead... try 'em all, then... TRY HOBART!

LARITY CONTROL. Straight or reverse larity selected at the flip of a finger give best results for any type elec-de. Quick reading meters give visual rity check at all times.



COMPACT SINGLE UNIT DESIGN. 100% all-welded steel construction eliminates heavy, brittle cast iron. All rotating parts are mounted between bearings on a heavy duty shaft.

EXCLUSIVE REMOTE CONTROL is standard on all Hobart Welders, comes at no extra cost. Particularly valuable when welding at great distance from machine.

Get this new HOBART ARC WELDING DESIGN SERVICE

Issued Semi-Monthly - Worth Hundreds of Dollars To You

Initial editions are FREE if you're interested in redesigning your product for Arc Welding, and will tell us on your letterhead about your plans and present equipment.

HOBART BROTHERS COMPANY, BOX WJ-74 TROY, OHIO

Descriptive Catalog Ask for Yours FREE!

HOBART "Simplified" ARC WELDERS

HOBART BROS. CO.,
BOX WJ-74 TROY, OHIO

Please send me information on items checked, without obligation.

☐ Gas Drive Welder ☐ Electric Drive Welder

☐ "Practical Design" Sheets ☐ Vest Pocket Welder's Guide ☐ Complete Hobart Welder Catalog

NAME_____

POSITION_____

ADDRESS_____

...y MORE War Bonds!

The Journal of the American Welding Society

Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

JULY, 1944

VOLUME 23 NUMBER 7

OFFICERS—1943-1944
President, DAVID ARNOTT
First Vice-President, ISAAC HARTER
Second Vice-President, A. C. WEIGEL
Treasurer, O. B. J. FRASER
Secretary, M. M. KELLY
Technical Secretary, L. M. DALCHER
(On Leave of Absence)
Acting Technical Secretary, SIMON A. GREENBERG

District Vice-Presidents
District #1 (New York & New England)—F. C. FYKE
District #2 (Mid-Eastern)—H. W. LAWSON
District #3 (Southern)—E. C. CHAPMAN
District #4 (Central)—C. H. JENNINGS
District #5 (Mid-Western)—G. N. SIEGER
District #6 (Mid-Southern)—B. W. FARQUHAR
District #7 (Western)—J. C. GOWING

ISSUED MONTHLY

Copyright 1944, by
The American Welding Society

Subscription $5.00 per year in United States and possessions; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents.

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York 18, N. Y.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication provided proper credit is given.

CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

Underwater Cutting of Metal, by M. F. Rodman 603
Metallic Arc-Welding Electrodes, by Harold Lawrence 610
Sectional Ship Erection Welding Sequence, by Alfred E. Wallen. 622
Hints on Silver Brazing, by H. H. Griffith 624
Three-Dimensional Lofting as an Aid in Jig Construction, by John W. Clerke 626
Unique Jig Speeds Welding of Canteens, by W. F. Lautner 630
Current Welding Literature 632

SOCIETY AND RELATED ACTIVITIES

Structural Failures in Welded Ship Construction 634
Machine Flame Cutting for Assembly Line Fabrication 634
Acknowledgment 634
Craftsweld Corporation Honored 634
Flame Thrower Demoralizes Enemy. 634
Welding's Place in Conserving Metal 634
X-Ray Bulletin 634
Silver-Brazed Hand Grenades 634
Piping Chart 634
Index to Advertisers 636
Hugo W. Hiemke with National Research Council 638
Locomotive Parts Fabrication 638
Welding Compound 638
The Extrusion of Metals 642
Joins Eutectic Engineering Staff 642
Welded Platform for U-Boat Liquidator 642
Unusual Repair Job on Extrusion Press, by George H. Smith 644
Third "E" Award to Summerill 644
Mobile Electric Power Stations 646
Wind Tunnel 646
Employment Service Bulletin 648
Section Activities 650
Welding Positioner 658
New Products 660
List of New Members 66
Members Reclassified 6
Postwar Use of Light Metals, Especially Aluminum Alloys 66
Tentative Program 25th Annual Meeting 670

WELDING RESEARCH SUPPLEMENT

Mechanical Characteristics of Resistance Welds in Plain Carbon Steels, A Review of the Literature, by W. Spraragen and M. A. Cordovi. 305-s
A Paper on Multi-Arc Welding of Aluminum Alloys, by M. R. Rivenburgh and C. W. Steward 344-s
Bursting Tests on Notched Alloy Steel Tubing, by G. Sachs and J. D. Lubahn 351-s
Fatigue Tests on Arc-Welded 3% Nickel Steel, by F. W. Thorne, A. Hunter and A. I. Hipperson ... 357-s

The Journal of
The American Welding Society
VOLUME 23 • NUMBER 7 • JULY, 1944

Underwater Cutting of Metal*

By M. F. Rodman

Introduction

UNDERWATER cutting of metals is a very practicable process. To the author's knowledge no comprehensive paper dealing in a general manner with difficulties, basic principles and applicability of the process has been produced. It is with this purpose in mind that this thesis has been written. Several phases of the subject will be ignored.

No attempt will be made to deal with the application of underwater cutting as a manufacturing process, although some of the material contained herein bears on that process. Although the oxidation and erosion of iron will be investigated, because it is present in all cutting, the chemistry of preheating flames and the physics of the electric arc will not be dealt with because of the unnecessary detail involved. The detail of design and operation of specific equipment, except for illustration, will be left for the reader to investigate when he finds that necessary. As a means of avoiding repetition the term "underwater" modifying "process" and "torch" will be omitted except in contrast to a surface "process" or "torch." Whenever the torch or cutting process refers to that above water it will be so stated. Torches using liquid fuels will be included under gas torches for the purpose of this thesis although this is not technically correct. The torches using gas and electricity as a means of preheating will be referred to as gas or arc torches, respectively.

Before presenting a description of the torch, an attempt will be made to discuss briefly the limitations that diving places on the operation of a torch. Basic to cutting all ferrous metals, no matter what type of torch is used, is the process of cutting by a jet of oxygen impinging on the metal which has been brought to the kindling temperature by either a gas flame or an electric arc. After dealing with the above subjects the author will go on to describe the general principles, structure and operation of arc and gas torches, the speed of cutting, the equipment and applications.

Other means of cutting metals have been employed. Dynamite will sever metal, leaving a torn edge; however the violence of the explosion very often deforms the whole structure. There are several mechanical devices; such as hand and power saws, drills and chisels. These have not proved themselves to be a very great success because of slowness and of the energy required of the diver to operate them.

Thus it can be recognized that, although until recently, it has been very much in the experimental stage, this cutting process is very useful. Engineers desiring to place temporary metal structures under water may do so with the assurance in many cases that much of the metal can be recovered economically. Much metal has been salvaged both in a usable form and as scrap from such submerged structures as bridges and ships.

* Thesis submitted to the faculty of applied science and engineering of the University of Toronto as a requisite for the degree of Bachelor of Applied Science, December 1943.

I—Diving Conditions

A torch may be operated anywhere that it is possible for a diver to work. The apparel of a diver hinders his movements so that work is very difficult. The success and speed of cutting operations are greatly dependent on the conditions which affect the diver. Great depth, fast current, low temperature, poor visibility and unstable footing are all detrimental to the diver's ability to work. Thus it is important to bear in mind the above factors when considering the use of cutting.

Depth

If other conditions remain the same, the diver's efficiency decreases directly with his depth. Just under the surface he can work for an indefinite period of time because he is limited only by the encumbrance of his diving gear. As he goes deeper the pressure imposes limitations on his physical ability to work. Below a depth of 150 ft. he cannot work well. The deeper he goes the more time he must spend getting used to the change of pressure. At a depth of approximately 150 ft. the time of adjustment equals the period of sustained work. Thus he would only spend one-half of his time usefully at the job. The maximum depth, at which diving in the conventional suit has been done, is around 200 ft. By means of a diving bell salvage work has been done at depths down to 400 ft.

Footing and Current Velocity

Unstable footing and fast currents also hinder one's efficiency. Torches have been operated in tidal waters having an average velocity of 6 mph., but slower rates of flow are desirable. If the footing is good a diver can stand up against a stronger current than otherwise. Unfortunately, many jobs are done where the footing is poor. It would seem that in fast water the soft material would be swept away leaving better material to stand on. It is obvious, however, that no such rigid rule can be drawn up.

Visibility

Good visibility is a great aid to the speed of work. Visibility varies with location and depth. In some operations no artificial light is required; in others, powerful lighting leaves the operator in the darkness on account

of silt and other suspended matter. When there is no visibility the work is slowed down a great deal because everything has to be done by a sense of touch.

Temperature

Low temperatures require more clothing and thus more encumberances. On one operation, with water temperature varying down to 30° F. and in depths of from 25 to 70 ft., the clothing worn was four suits of heavy woollens, one heavy sweater, fleece-lined woollen headgear, four pairs of homespun socks and two-ply woollen gloves. Thus equipped, the divers were able to stay down for periods of 60 to 110 min. until either their fingers or air lines became frosted. Thus, at depths where it would take 1 hr. or more for the body to make the pressure adjustment, including lowering and raising, it would be impossible for the diver to get any work done. Fortunately for the application of this process most of the work has to be done in either shallow or warm water, or in both shallow and warm water.

Evidently then subsurface water conditions should be carefully considered before undertaking any cutting project. Success may be limited, and often is prevented, by a bad combination of the above conditions. Diving conditions affect the efficient, cutting equipment.

II—Cutting Principles

A jet of oxygen, under high pressure, removes the preheated metal from the kerf (the space from which metal is removed) by oxidation and erosion. This is the basic principle of both underwater and surface torches. However, the metal must be brought to and kept at the kindling temperature for the jet of oxygen to function. This preheating is done by an electric arc or a gas flame using various fuels mixed with oxygen. In each, the preheating agent surrounds the oxygen jet.

Chemistry of the Oxidation of Iron

The chemical formula of the iron oxide formed in cutting is Fe_3O_4, the same as hammer scale on magnetite ore. It contains a smaller proportion of oxygen than rust or red iron oxide, Fe_2O_3. The chemical equation for its formation is:

$3Fe$	$+ 2O_2$	$=$	$Fe_3O_4 + 26{,}691$ cal.
3 mol. wt.	+ 2 mol. wt.	=	1 mol. wt.
iron	oxygen		black iron oxide

This means that three atoms of iron (Fe) combine with two molecules of oxygen (O_2) to produce one molecule of black iron oxide, Fe_3O_4. This oxidation reaction is exothermic because it gives off 2870 Btu. per pound of iron oxidized. From the atomic weight of iron (Fe), 5584, and the molecular weight of oxygen (O_2), 32, the relative weights of iron and oxygen in Fe_3O_4 are calculated to be 2.618 to 1. Therefore 1 lb. of oxygen will oxidize 2.618 lb. of pure iron to Fe_3O_4. Oxygen at 70° F. and 1 atmos. pressure has a volume of 12.07 cu. ft. per pound and pure iron weighs 0.285 lb. per cubic inch. Therefore 1 cu. in. of pure iron requires, for oxidation, 0.109 lb. or 1.314 cu. ft. of oxygen.

Erosion by Oxygen

The iron removed from the kerf in cutting is not consumed entirely by the oxygen. Between 30 and 40% of the metal is washed out by the eroding effect of the oxygen jet. With the aid of this effect it is common to remove metal from the kerf at a rate of 1 cu. in. per cubic foot of oxygen consumed. This gives a removal of metal of 30% better than the theoretical value based on chemical reaction alone.

Heat Required

Assuming 65% of the iron to be oxidized to magnetite (Fe_3O_4) the exothermic heat will be 531.7 Btu. per cubic inch of metal removed from the kerf. This is at least twice as much heat as is supplied by the preheating flames of the oxyacetylene torch (for example) in light cutting, and this ratio increases rapidly with the thickness. The average specific heat of pure iron between 70 and 1500° F. is 0.1597, so that, theoretically, only about 65.1 Btu. per cubic inch would be required to raise the metal to the kindling temperature. It might appear that, once the cut was started, the oxidation would give off enough heat to maintain the kindling temperature. Thus the preheating flame could be cut off and cutting would continue with only the jet oxygen on. This actually is done with some classes of work. Ordinarily there is too much heat lost in the oxides and molten metal blown out of the kerf, and by conductance to the adjacent metal and radiation, to allow this reaction to continue unassisted. Therefore, sufficient heat must be continuously added to raise the new surface to the kindling temperature.

Alloys in steels such as chromium and nickel as well as graphite carbon in cast iron tend to retard oxidation. Brass is not oxidized by the oxygen jet of a conventional torch. Thus in cutting these metals the eroding effect of the oxygen is the chief factor. It is easily seen that the action of the central high-pressure oxygen jet is the fundamental process in cutting. Fortunately it is easy to control. The preheating agent, in the case of gas torches, requires delicate control and sturdy protection for use under water.

III—The Gas Torch

The study of the removal of iron by oxidation and erosion was a prerequisite to an investigation into the various torch types. The chief difference between the underwater and the surface torch is that it is necessary to protect the preheating flame of the underwater torch. Underwater torches use, as preheating fuels with oxygen, acetylene to a depth of 30 ft., or hydrogen, or combustible vaporizing liquids at any depth. They require higher gas pressures than surface torches, and they can be ignited either at the surface or under water.

Heat Conservation

Necessity of Insulation.—Most torches designed for surface work may be operated under water at very shallow depths; however, the flame is very unstable. Since water has a conductivity of 40 times as great as that of air, it is necessary to insulate both the flame and metal. The flame must be insulated to prevent quenching and conserve heat. The metal must be insulated to prevent radiation to the water.

Development of Present Methods.—Present-day torches developed from a crude beginning. An early shielded tip consisted of a box with a sliding cover fitted around the tip. While the flame burned in the box, the products of combustion escaped through an opening. The box was rested on the object to be cut, the cover slid back and the flame impinged on the metal. Simultaneously a jet of compressed air prevented water from touching the flame. In 1913 one experimenter substituted an open bell for the closed chamber. Other experimenters did away with the awkward bell by surrounding the preheating flame with an annular air jet. The tip of these torches consisted of three concentric nozzles, Fig. 1. About 1924 a torch was produced which made use of the outer envelope of burnt gases to protect the inner flames.

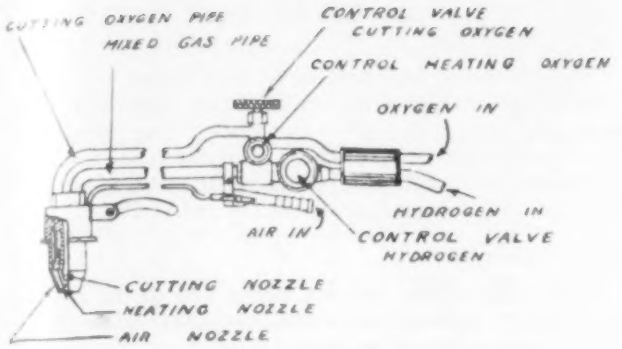


Fig. 1—Compressed Air Jacket Torch

At present then there are two main types of gas torches: namely, that using the compressed air jacket and that using a burnt gas jacket. It is only possible to treat the main features of these types in the following sections.

Compressed Air Jacket.—The compressed air jacket, which protects the preheating flame and oxygen jet, emerges from a circular opening completely surrounding the inner tip. The outer surface of the compressed air envelope is guided by a bell while the inner surface is bordered by the preheating flames. Since it is necessary to let the hot inner cone of the preheating flame impinge on the metal, the bell, acting as a spacer, extends beyond the inner tip about two-thirds of the length of this inner cone. Some torches, designed to use more than one type of fuel gas, have this distance adjustable to allow for varying lengths of flame.

Guides are used, sometimes, to keep this bell at the proper distance from the object to be cut so that the compressed air and products of combustion can escape. Some manufacturers recommend that their torches be tilted for the escape of the gas; others recommend that the bell be held tightly against the surface in order to force all the gases through the kerf. This latter method helps erode the molten metal but loses the insulating effect of gases on the metal surface toward the torch. There is also more heat absorbed from the kerf by this extra gas passing through. If the air is cut off, the torch will burn but will not cut. Thus the air conserves heat and permits the temperature of the steel to be raised high enough to be cut. Nitrogen is as effective as air but is less procurable. There are usually air compressors around any construction job on which underwater cutting would be employed.

Jacket of Burnt Gases.—Besides hampering the diver and diver's crew with an additional hose and compressor, respectively, compressed air increases the preheating time. Furthermore, the backward reaction caused by the compressed air and decreased visibility due to extra bubbling are troublesome. Some compressed air torches cannot be pointed upward without extinguishing the flame. Consequently, Picard, adapting his observation that a particular type of oxyacetylene torch will not be extinguished if it is lowered into the water with the flame pointed upward, utilizes the products of combustion to shield the flame. The diameter of the end of the protecting chamber is such that the walls of the chamber are tangential too, or make contact with (so as to compress slightly) the exterior of the jacket of products of combustion surrounding the flame. The dimensions of the chamber are calculated from the length of the flame cone. The diameter of the chamber is made nine-tenths of the diameter of the gaseous jacket; the length is made two-thirds the length of the flame cone. If the protected flame is unstable the diameter is reduced. Figure 2 shows the tip of Picard's torch with the pilot.

Preheating Fuels

Acetylene.—As long as combustion is too rapid for the quenching action of the water to be effective any fuel can be used. It is not recommended to use acetylene below a depth of about 30 ft. where pressures of 25 to 30 psi. are used. There seem to be many conflicting views on this subject. At pressures below 30 psi. the acetylene is decomposed causing an unstable flame. Backfiring may occur which will damage the equipment. When a torch goes out the gases may rise to the surface and explode. Therefore great care must be exercised to keep the torch burning or to shut it off when it goes out. There are low-pressure torches which permit the use of acetylene at depths as low as 200 ft. but these seem to be somewhat unsatisfactory and not in general use. One

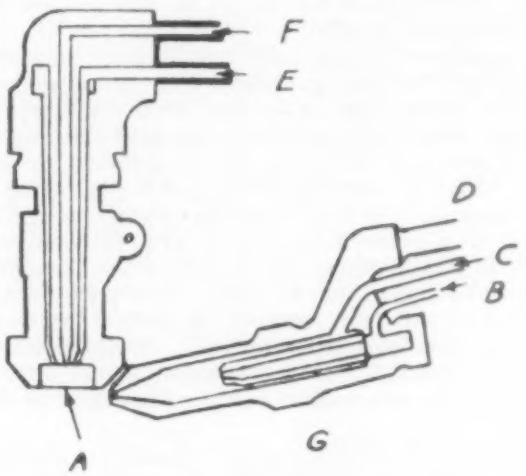


Fig. 2—Sketch of Torch and Pilot Used by Picard
A, protecting chamber; *B*, oxygen for pilot; *C*, acetylene for pilot; *D*, movable support for pilot; *E*, mixture of oxygen and acetylene for preheating; *F*, cutting oxygen; *G*, movable pilot.

torch was designed with a device to stop the effect of backfiring which extended its depth to 65 ft.

Hydrogen.—Since acetylene is not satisfactory, except in shallow water, most torches for cutting at great depths are operated with hydrogen. It seems to have no depth limitation; cuts have been made as deep as 130 ft. The hydrogen torch is therefore better where both deep and shallow water are encountered. Although the hydrogen flame is not as hot as the acetylene flame it is more stable.

Liquids.—Liquid fuels also have been used. One torch vaporizes the combustible liquid (gasoline, benzol, benzol-alcohol mixture, etc.) in a serpentine passage heated by an electric resistance. The flame surrounds the oxygen jet in the usual way. Another torch is made without a protecting jacket, and in another there is a heat recuperator surrounding the oxygen and fuel nozzles in the tip, which, in turn, is surrounded by an insulating chamber of dead gas.

Operation

Gas Pressure.—Gas pressures for the underwater cutting torch are higher than the pressures for the surface torch for two reasons; namely, that the flame intensity must be greater to allow for the rapid heat dissipation and the hydrostatic pressure of the water must be overcome. The pressure increase for hydrostatic pressure is approximately $^1/_2$ psi. per foot depth (salt water has a slightly greater increase). The initial gas pressures vary with design of the torch, the kind of gas and the thickness of metal. The pressure of the cutting oxygen is usually higher than the pressure of the preheating gases. Because this oxygen, traveling at a high velocity, does not

of silt and other suspended matter. When there is no visibility the work is slowed down a great deal because everything has to be done by a sense of touch.

Temperature

Low temperatures require more clothing and thus more encumberances. On one operation, with water temperature varying down to 30° F. and in depths of from 25 to 70 ft., the clothing worn was four suits of heavy woollens, one heavy sweater, fleece-lined woollen headgear, four pairs of homespun socks and two-ply woollen gloves. Thus equipped, the divers were able to stay down for periods of 60 to 110 min. until either their fingers or air lines became frosted. Thus, at depths where it would take 1 hr. or more for the body to make the pressure adjustment, including lowering and raising, it would be impossible for the diver to get any work done. Fortunately for the application of this process most of the work has to be done in either shallow or warm water, or in both shallow and warm water.

Evidently then subsurface water conditions should be carefully considered before undertaking any cutting project. Success may be limited, and often is prevented, by a bad combination of the above conditions. Diving conditions affect the efficient, cutting equipment.

II—Cutting Principles

A jet of oxygen, under high pressure, removes the preheated metal from the kerf (the space from which metal is removed) by oxidation and erosion. This is the basic principle of both underwater and surface torches. However, the metal must be brought to and kept at the kindling temperature for the jet of oxygen to function. This preheating is done by an electric arc or a gas flame using various fuels mixed with oxygen. In each, the preheating agent surrounds the oxygen jet.

Chemistry of the Oxidation of Iron

The chemical formula of the iron oxide formed in cutting is Fe_3O_4, the same as hammer scale on magnetite ore. It contains a smaller proportion of oxygen than rust or red iron oxide, Fe_2O_3. The chemical equation for its formation is:

$3Fe$	$+ 2O_2$	$=$	$Fe_3O_4 + 26{,}691$ cal.
3 mol. wt.	+ 2 mol. wt.	=	1 mol. wt.
iron	oxygen		black iron oxide

This means that three atoms of iron (Fe) combine with two molecules of oxygen (O_2) to produce one molecule of black iron oxide, Fe_3O_4. This oxidation reaction is exothermic because it gives off 2870 Btu. per pound of iron oxidized. From the atomic weight of iron (Fe), 5584, and the molecular weight of oxygen (O_2), 32, the relative weights of iron and oxygen in Fe_3O_4 are calculated to be 2.618 to 1. Therefore 1 lb. of oxygen will oxidize 2.618 lb. of pure iron to Fe_3O_4. Oxygen at 70° F. and 1 atmos. pressure has a volume of 12.07 cu. ft. per pound and pure iron weighs 0.285 lb. per cubic inch. Therefore 1 cu. in. of pure iron requires, for oxidation, 0.109 lb. or 1.314 cu. ft. of oxygen.

Erosion by Oxygen

The iron removed from the kerf in cutting is not consumed entirely by the oxygen. Between 30 and 40% of the metal is washed out by the eroding effect of the oxygen jet. With the aid of this effect it is common to remove metal from the kerf at a rate of 1 cu. in. per cubic foot of oxygen consumed. This gives a removal of metal of 30% better than the theoretical value based on chemical reaction alone.

Heat Required

Assuming 65% of the iron to be oxidized to magnetite (Fe_3O_4) the exothermic heat will be 531.7 Btu. per cubic inch of metal removed from the kerf. This is at least twice as much heat as is supplied by the preheating flames of the oxyacetylene torch (for example) in light cutting, and this ratio increases rapidly with the thickness. The average specific heat of pure iron between 70 and 1500° F. is 0.1597, so that, theoretically, only about 65.1 Btu. per cubic inch would be required to raise the metal to the kindling temperature. It might appear that, once the cut was started, the oxidation would give off enough heat to maintain the kindling temperature. Thus the preheating flame could be cut off and cutting would continue with only the jet oxygen on. This actually is done with some classes of work. Ordinarily there is too much heat lost in the oxides and molten metal blown out of the kerf, and by conductance to the adjacent metal and radiation, to allow this reaction to continue unassisted. Therefore, sufficient heat must be continuously added to raise the new surface to the kindling temperature.

Alloys in steels such as chromium and nickel as well as graphite carbon in cast iron tend to retard oxidation. Brass is not oxidized by the oxygen jet of a conventional torch. Thus in cutting these metals the eroding effect of the oxygen is the chief factor. It is easily seen that the action of the central high-pressure oxygen jet is the fundamental process in cutting. Fortunately it is easy to control. The preheating agent, in the case of gas torches, requires delicate control and sturdy protection for use under water.

III—The Gas Torch

The study of the removal of iron by oxidation and erosion was a prerequisite to an investigation into the various torch types. The chief difference between the underwater and the surface torch is that it is necessary to protect the preheating flame of the underwater torch. Underwater torches use, as preheating fuels with oxygen, acetylene to a depth of 30 ft., or hydrogen, or combustible vaporizing liquids at any depth. They require higher gas pressures than surface torches, and they can be ignited either at the surface or under water.

Heat Conservation

Necessity of Insulation.—Most torches designed for surface work may be operated under water at very shallow depths; however, the flame is very unstable. Since water has a conductivity of 40 times as great as that of air, it is necessary to insulate both the flame and metal. The flame must be insulated to prevent quenching and conserve heat. The metal must be insulated to prevent radiation to the water.

Development of Present Methods.—Present-day torches developed from a crude beginning. An early shielded tip consisted of a box with a sliding cover fitted around the tip. While the flame burned in the box, the products of combustion escaped through an opening. The box was rested on the object to be cut, the cover slid back and the flame impinged on the metal. Simultaneously a jet of compressed air prevented water from touching the flame. In 1913 one experimenter substituted an open bell for the closed chamber. Other experimenters did away with the awkward bell by surrounding the preheating flame with an annular air jet. The tip of these torches consisted of three concentric nozzles, Fig. 1. About 1924 a torch was produced which made use of the outer envelope of burnt gases to protect the inner flames.

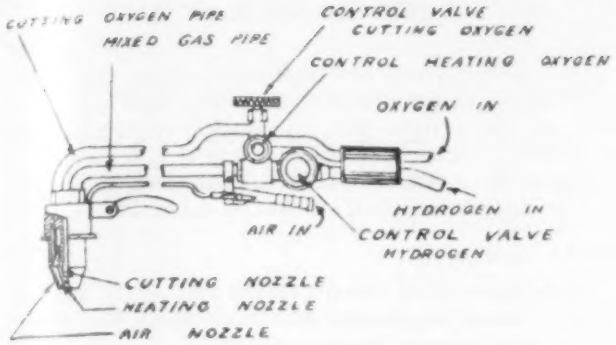


Fig. 1—Compressed Air Jacket Torch

At present then there are two main types of gas torches: namely, that using the compressed air jacket and that using a burnt gas jacket. It is only possible to treat the main features of these types in the following sections.

Compressed Air Jacket.—The compressed air jacket, which protects the preheating flame and oxygen jet, emerges from a circular opening completely surrounding the inner tip. The outer surface of the compressed air envelope is guided by a bell while the inner surface is bordered by the preheating flames. Since it is necessary to let the hot inner cone of the preheating flame impinge on the metal, the bell, acting as a spacer, extends beyond the inner tip about two-thirds of the length of this inner cone. Some torches, designed to use more than one type of fuel gas, have this distance adjustable to allow for varying lengths of flame.

Guides are used, sometimes, to keep this bell at the proper distance from the object to be cut so that the compressed air and products of combustion can escape. Some manufacturers recommend that their torches be tilted for the escape of the gas; others recommend that the bell be held tightly against the surface in order to force all the gases through the kerf. This latter method helps erode the molten metal but loses the insulating effect of gases on the metal surface toward the torch. There is also more heat absorbed from the kerf by this extra gas passing through. If the air is cut off, the torch will burn but will not cut. Thus the air conserves heat and permits the temperature of the steel to be raised high enough to be cut. Nitrogen is as effective as air but is less procurable. There are usually air compressors around any construction job on which underwater cutting would be employed.

Jacket of Burnt Gases.—Besides hampering the diver and diver's crew with an additional hose and compressor, respectively, compressed air increases the preheating time. Furthermore, the backward reaction caused by the compressed air and decreased visibility due to extra bubbling are troublesome. Some compressed air torches cannot be pointed upward without extinguishing the flame. Consequently, Picard, adapting his observation that a particular type of oxyacetylene torch will not be extinguished if it is lowered into the water with the flame pointed upward, utilizes the products of combustion to shield the flame. The diameter of the end of the protecting chamber is such that the walls of the chamber are tangential too, or make contact with (so as to compress slightly) the exterior of the jacket of products of combustion surrounding the flame. The dimensions of the chamber are calculated from the length of the flame cone. The diameter of the chamber is made nine-tenths of the diameter of the gaseous jacket; the length is made two-thirds the length of the flame cone. If the protected flame is unstable the diameter is reduced. Figure 2 shows the tip of Picard's torch with the pilot.

Preheating Fuels

Acetylene.—As long as combustion is too rapid for the quenching action of the water to be effective any fuel can be used. It is not recommended to use acetylene below a depth of about 30 ft. where pressures of 25 to 30 psi. are used. There seem to be many conflicting views on this subject. At pressures below 30 psi. the acetylene is decomposed causing an unstable flame. Backfiring may occur which will damage the equipment. When a torch goes out the gases may rise to the surface and explode. Therefore great care must be exercised to keep the torch burning or to shut it off when it goes out. There are low-pressure torches which permit the use of acetylene at depths as low as 200 ft. but these seem to be somewhat unsatisfactory and not in general use. One

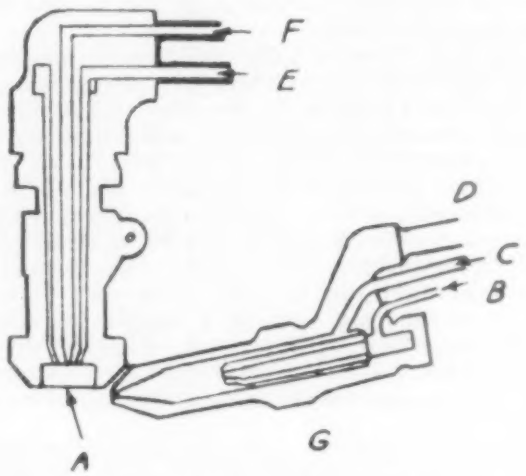


Fig. 2—Sketch of Torch and Pilot Used by Picard
A, protecting chamber; *B*, oxygen for pilot; *C*, acetylene for pilot; *D*, movable support for pilot; *E*, mixture of oxygen and acetylene for preheating; *F*, cutting oxygen; *G*, movable pilot.

torch was designed with a device to stop the effect of backfiring which extended its depth to 65 ft.

Hydrogen.—Since acetylene is not satisfactory, except in shallow water, most torches for cutting at great depths are operated with hydrogen. It seems to have no depth limitation; cuts have been made as deep as 130 ft. The hydrogen torch is therefore better where both deep and shallow water are encountered. Although the hydrogen flame is not as hot as the acetylene flame it is more stable.

Liquids.—Liquid fuels also have been used. One torch vaporizes the combustible liquid (gasoline, benzol, benzol-alcohol mixture, etc.) in a serpentine passage heated by an electric resistance. The flame surrounds the oxygen jet in the usual way. Another torch is made without a protecting jacket, and in another there is a heat recuperator surrounding the oxygen and fuel nozzles in the tip, which, in turn, is surrounded by an insulating chamber of dead gas.

Operation

Gas Pressure.—Gas pressures for the underwater cutting torch are higher than the pressures for the surface torch for two reasons; namely, that the flame intensity must be greater to allow for the rapid heat dissipation and the hydrostatic pressure of the water must be overcome. The pressure increase for hydrostatic pressure is approximately $^1/_2$ psi. per foot depth (salt water has a slightly greater increase). The initial gas pressures vary with design of the torch, the kind of gas and the thickness of metal. The pressure of the cutting oxygen is usually higher than the pressure of the preheating gases. Because this oxygen, traveling at a high velocity, does not

diffuse with the other gases it thus contacts the heated metal in a pure state. Gas pressure tables are supplied for use with each make of torch by its manufacturer.

Ignition.—There are two methods of ignition; one is to light the torch at the surface and increase gas pressure with depth; the other is to set the pressure previously and ignite the torch by a spark or other means at the desired depth. In submerged ignition, especially in a confined place, a slight explosion often occurs which is somewhat annoying to many new operators. For work at great depths much gas would be wasted in surface ignition because a great deal of time is required for descent and ascent. However, in clear water with no current, where the torch could be lowered from the surface, this would be a very satisfactory method. Where a diver has to do other operations, besides cutting, it would be convenient for him to be able to shut off and ignite his torch at will.

Underwater igniters take two forms: namely, the electric spark and the gas pilot. The current in one electric type comes from an alkaline solution battery (10 v., 45 amp.) which will withstand repeated shorting. One wire is attached to the torch, the other to an ignition plate, which is touched by the guide pin of the torch when ignition is desired. Another method of ignition is by the use of a pilot flame, Fig. 2. The flame burns principally in the chamber, only the end of the flame projecting beyond the tip of the pilot. The pilot flame may swivel from the torch itself, or, if quarters are cramped, the pilot may be a separate torch. Powders have also been used, which ignite spontaneously upon contact with water such as, ferrocerium calcium phosphide or sodium metal.

Operational Technique.—The technique of guiding the torch along the cut is practically the same under water as in air. It is advisable for divers to have enough practice to get familiar with the torch at the surface before actually starting to work. Efficient manipulation can only be acquired by practice. Manufacturers usually supply instructions for the use of their torches, dealing with means of ignition and pressure adjustments. Starting the cut is sometimes difficult. It has been found easier to start several inches from the edge of a plate or object to be cut. Before the oxygen jet can be turned on the preheating flame must bring the metal to the kindling temperature. At the edge the water conducts away too much heat to allow this temperature to be reached. Further from the edge the heat is conserved by the methods previously described.

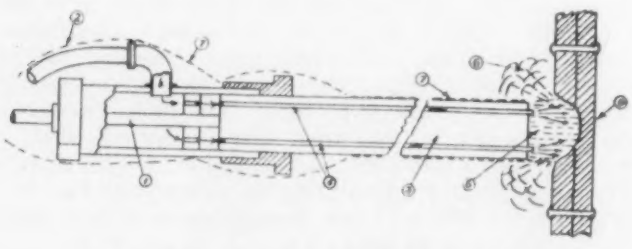


Fig. 3—Principle Parts of the Oxyelectric Torch

1, electrical conductor; *2*, oxygen connection; *3*, carbon electrode; *4*, small pipes through electrode by which oxygen reaches the tip; *5*, flaming arc; *6*, vaporous cavity in which the arc burns the metal to be cut; *7*, covering of friction tape to insulate the torch; *8*, steel plates being cut.

It would seem then that the underwater torch is basically the same as the surface torch. The flame requires protection; the fuels are varied and the operation is somewhat more difficult.

IV—The Arc Torch

The arc torch was first developed about 1915. It is very simple in construction and operation and can be used anywhere that a diver can work. Arc torches, also, have been produced in a wide variety of types and forms.

The torch consists of a holder for an electrode to which lead an oxygen hose and an electric cable, Fig. 3.

Electric Current

While alternating current might add to the efficiency of the torch, although some writers claim it is less efficient, direct current is used because it is safer.

A torch, energized by direct current, is less likely to shock an operator if he gets too close to the electrode. The electrode must be positive to prevent the formation of an explosive mixture of hydrogen and oxygen. The speed of cutting and consumption of the electrode are proportional to current being used. It is desirable to have an absolutely constant potential under varying loads. One kind of graphite electrode 12 in. long, which was used up in about 30 min., uses from 400 to 1000 amp. and 90 to 100 v. (220 amp. and 55 v. are said to be a minimum). Another, slag-covered and varnished steel electrode, used 150 to 180 amp. direct current or 225 to 250 amp. alternating current both at 55 v.

Electrodes

The electrodes used may be of carbon, graphite or metal. Most electrodes are tubular in order to introduce a jet of oxygen into the molten kerf created by the arc, thus causing combustion of the metal. There is also eroding action by the jet of oxygen on the molten metal as in the gas torch. In practical work the shape of the cross section of the electrode seems to be of little importance; however, the smaller the cross section the greater will be the cutting speed with the same current, due, of course, to the greater current density.

Operation

The operation of the arc torch is simple in theory but difficult in practice. The diver attaches a negative plate to the metal to be cut and strikes an arc by first touching the end of his electrode to that point of the object where he wants to start cutting, and then withdraws it until he has a long electric arc between the end of the electrode and the metal to be cut. The heat of the arc causes a globe to form around the arc, which is further increased when the oxygen flowing through the carbon, is projected on the surface of the melting metal. Apparent difficulties, as a result of the conductivity of water, are hereby overcome. The arc is constantly keeping this bubble or blanket of steam intact while the oxygen, at a pressure of about 50 psi. above water pressure, blows any molten metal from the cut. The result is a remarkably clean cut which looks more like a cut with an oxyacetylene flame than that of an electric arc.

Knowing how dazzling is the light of an electric arc, one is surprised to hear that divers sometimes have to toil in waters so thick with silt in suspension that the arc of the torch is invisible a foot away from the faceplate of the hood. When working under such conditions, the diver has to depend upon his ear to inform him whether or not the torch is functioning. An active arc under water sounds like a boiling kettle; and to that sound is added a singing note that is punctuated with the crackling explosions of bits of metal undergoing rapid expansion and contraction. These sounds indicate that the diver is holding the electrode the right distance away from the metal to be cut. It takes experience to handle the torch correctly in such a position.

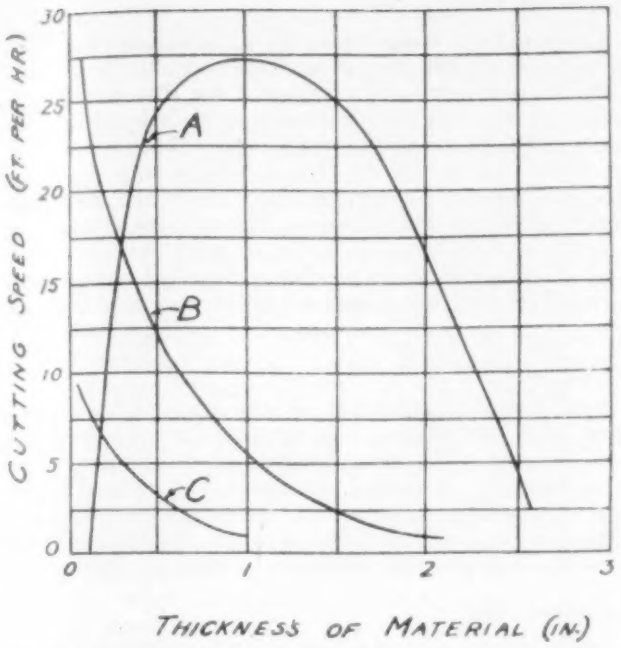


Fig. 4—Comparative Speeds of Underwater Arc and Gas Cutting

The arc torch is simpler in construction than the gas torch. The fundamental principle of cutting is used by it also. The electric arc which replaces the gas preheating agent is simpler to adjust but more difficult to operate.

V—Rate of Cutting

As has been noted in Section I the speed and success of underwater operations are greatly dependent on the conditions under which the work is done. Other factors entering into the speed of cutting are the condition of the metal, the kind of metal and the skill and experience of the diver and his crew. The arc torch is faster on thin metal than the gas torch is; whereas the gas torch has superior speed on the thicker cuts.

Corrosion

Ferrous metals corrode very quickly especially in salt water. Usually up to a period of 1 yr. this corrosion is not very serious. However, in a period of several years this scale becomes thick enough that its refractory properties are a serious handicap to cutting. Much of it can be removed if the proper tools and methods are used.

Comparative Speeds of Arc and Gas

The curves in Fig. 4 are meant to show the comparative rates of cutting on various metals by the arc and gas torches. They represent the performance expected with an experienced operator under good diving conditions and a convenient position at a depth of about 8 ft. Thus, these speeds cannot be used directly to calculate speed of cutting but rather serve to give a standard on which to base a judgment of speed.

Comparative cutting speeds on medium steel by gas and arc torches are shown by curves *A* and *B*. Curve *A* represents the cutting speed of the oxyhydrogen torch using a medium-sized tip (1 oxygen orifice No. 45 drill size and 4 fuel orifices No. 52 drill size). *B* represents the average speeds of three different arc torches. Curve *C* for the same arc torches for brass, cast iron and stainless steels. As can be seen from the curves, the arc torches are much more efficient than the gas torches on metal under about $^3/_8$ in. thick. This is because there is a greater current density on thin than on thick metal and therefore there is more heat per unit volume of metal removed. The greater heat loss per unit volume from the thin metal is therefore small compared with the increased heat due to the increased current density. Comparing the arc torch with the gas, one finds that for the latter to operate efficiently, the metal should be at least $^1/_4$ in. thick. A large mass of metal holds the heat better because it has a small radiating surface per unit volume. The Curve *C* shows a slower rate for the arc torch on brass, cast iron and stainless steel because the oxidation reaction is very weak with these metals. Gas torches generally are not as successful as arc torches on these metals.

Some writers claim that the speed of the underwater gas torch is 4 to 5 times faster than its surface counterpart. This may be so, as far as the cutting speed of the torch itself is concerned, but experience has shown that it takes a diver four to five times as long, in general, to complete a job under water as it would to complete the same job in air. This is obviously not a rigid rule.

Evidently then, the gas torch will cut faster and thus is used more on ordinary submerged steel structures. However, for thin steel, cast iron, stainless steel and brass the arc torch is more efficient provided there is enough work to warrant its use. Corrosion is a factor to be reckoned with. Underwater jobs take about four times as long as surface jobs. Good equipment helps prevent delays.

VI—Equipment

The equipment used on a job pertaining to the cutting itself depends on the type of torch being used, arc or gas. The detail under each of these types varies again with the make of torch. Other equipment that is independent of the torch and accessory to the job is also required.

Gas Torch Equipment

The equipment which supplies the torch depends on the type of torch being used. Picard's torch requires delicate pressure control for the burnt gas jacket principle. The pressures for compressed air jacket torches are regulated by the conventional regulator with gages. A safety valve to prevent damage from flashbacks is in use. Such a valve can also be attached at the torch and thus protect the hose. Valves are placed on the torch also to control the flow of gas at the tip. It is advisable that a number of gas cylinders be interconnected so that the flow of gas to the torch does not have to be stopped to change over from one cylinder to another. Cylinders are thus connected by manifolds. The following list of equipment by Charles Kandel serves as an illustration of what is required:

- The Ellsberg Torch with 90°, 75° or straight head in lengths varying from 15 to 36 in. or more, as may be required.
- Assortment of tips suitable for varying characteristics and thickness of steel and depth and condition of water to be encountered.
- Oxygen and hydrogen manifolds with necessary regulators to enable the diver to work continuously for the full diving period permissible at the depth of operation.
- Compressed air regulator for the control of compressed air at whatever pressure it may be available on the job.

Necessary lengths of heavy duty, cord-reinforced hose for the operation of the torch at a convenient distance from the base.

Sufficient spares to provide for reasonable contingencies.

Underwater torch lighter using 110 v. 10 amps., desirable for deep water or where operations are carried on at a considerable distance from the diving base.

Arc Torch Equipment

The accompanying equipment with the arc torch is very simple. Insulation of the torch is a prime essential in preventing shock to the diver. The following list includes most of the main items:

The electrode holder complete with spare electrodes.

A conduit-carrying oxygen hose and two electric cables (one for electrode and one for ground).

Oxygen cylinders with manifold and regulators.

One electric generator (or other supply) of a capacity of about 1000 amp. at 100 v.

Auxiliary Equipment

Equipment for diving according to Charles Kandel consists of the following:

Complete diving rig suitable for the operation in hand, including helmet, breastplate, several dresses, shoes, weighted belt, air line with control valve, life line, etc.

The above is generally packed in three cases: one containing helmet and breastplate weighing about 40 lb.; one containing shoes and weights totaling about 125 lb.; one containing balance of equipment and accessories weighing about 250 lb.

Diving pump—encased, weighing about 400 lb.

Two fly wheels, each weighing about 100 lb. crated.

Submarine searchlight (using 110 v. 10 amp.) with necessary cable and spare bulbs—300 watts—desirable for increasing the visibility under water.

Submarine flashlight with spare batteries, used for inspection work and where the cost of supplying necessary current for the searchlight is prohibitive.

Balanced high-pressure jetting nozzle—VeVac Model—for clearing and exposing work, dredging, etc., operating on water pressure up to 200 lb., supplied through ordinary hose having a 2- or $2^1/_2$-in. I.P. coupling. This nozzle is slightly self-propelling and can be held by a diver with one hand regardless of the pressure.

A pneumatic chipper for removing corrosion and other refractory material is very useful.

Kandel also recommends that the usual facilities necessary for carrying on operations include the following:

Diving platform, raft or scow with adequate space and shelter for dressing, for the operation of the diver's pump and for the storage of the oxygen and hydrogen cylinders actually in service. The pump and cylinders may be stored adjacent to the diving base.

Suitable derricks for holding, pulling and lifting material out.

Surface personnel for manning the diver's pump, handling cylinders, operating derrick and otherwise cooperating with diver and his tender in speeding up the work of cutting and removal of material after it is cut.

VII—Application

Companies which specialize in cutting can be called on to work at the salvaging of piles, ships and other structures.

Equipment Owners

Construction companies, in general, do not have enough use for the process to make it profitable to maintain a department and equipment for this specific purpose. In the last decade engineers have learned to depend on the process; the result is that there has been an increased demand for it. There being a large decentralized demand some companies have organized specialized departments for this purpose. The services of these concerns are available usually on a daily flat-rate basis. The unpredictability as to time and cost of completing a certain job very often does not facilitate a fixed cost contract.

Salvage of Piles

The largest application of the underwater process other than ship salvage is in cutting off steel piles driven under water. The piles forming pier cofferdams have often been cut off several feet above bottom level to protect the pier from water scour. Sometimes due to pulling difficulties it is more expedient to cut them off as low as possible and leave the remaining portion in place.

Salvage of Ships

Ship salvage is a very important task which is facilitated by the process. There are two main reasons for salvaging ships, one is for the recovery of the ship, as such, or for its cargo and scrap steel, the other is to clear any channel which the ship may be obstructing. Many ports have been almost completely blocked in World War II and would be greatly hampered were it not possible to remove the hulls. Holes are cut to admit divers for inspection, to allow the flow of water or compressed air from one compartment to another to fit valves for pumping operations and for many other purposes. Shipscrews often become fouled on wire cables; by the use of this torch the necessity of drydocking is avoided thus saving time and money.

Typical Jobs

The various jobs that have been done are too numerous to describe in complete detail. There have been more uses for the gas than the arc torch. However, one specific type of job that the latter alone is suited to is the repair and maintenance of cast-iron water mains which have been laid on the bed of a river or lake. The following is a typical list of tasks on which a gas torch (the Ellsberg Torch) has been used as compiled by Charles Kandel:

1. Salvaging of the U. S. Submarine S-51. Cutting conning tower, part of superstructure, anchor chain, steel cables, pontoon toggle bolts, etc., at 138 ft. depth in open sea.
2. Reconstruction of high bridge on Harlem River. Cutting steel bulkhead in the dry, against the incoming water, at a depth of 4 to 6 ft.
3. Construction of Perth Amboy–Tottenville Bridge. Cutting steel sheet piling forming part of cofferdam at a depth of 22 ft.
4. Salvaging of the U. S. Submarine S-4. Cutting part of superstructure and air inlet vents to match flanges, etc., at a depth of 105 ft. in open sea.
5. Construction of power house on Long Island Sound. Cutting steel sheet bulkhead in midwinter at temperatures as low as 13° F., at a depth of 25 ft.
6. Construction of railroad bridge caisson. Cutting 48-in. girders and other structural steel totaling about 15 tons inside caisson, at a depth of 95 ft., on bottom of mud and quicksand.

7. Reconstruction of steel trash rack at inlet to hydroelectric plant. Cutting 24-in. I-beam lines with 4-in. oak lagging on both sides of webs, and miscellaneous channels and bars totaling about 25 tons, drilling holes in concrete, setting templates, etc., at a depth of 25 to 70 ft. in water at 32° F.
8. Clearing of channel obstruction. Complete cross section of stern of wrought iron hull 45 ft. wide totaling about 90 tons, at a depth of 25 ft.
9. Construction of dry dock. Cutting steel sheet piling to provide overflow at a depth of 3 to 5 ft.
10. Construction of sewer outlet on Harlem River. Cutting steel cofferdam located in sewer outflow with zero visibility at a depth of 6 to 15 ft.
11. Construction of dry dock. Cutting of steel sheet piling to provide for extension of cradle at a depth of 2 to 4 ft. with zero visibility.
12. Placing of caisson (40 x 90 ft. in cross section) at a depth of 75 ft. Cutting and fitting pipe, drilling heavy timbers, jetting with balanced high-pressure nozzle—VeVac Model, etc., incidental to resetting caisson which had been overtaken by flood.

Therefore, it can be seen that this process has a very wide application in engineering work. Since skilled personnel is available only in limited numbers the United States Navy has established a school for training divers. There should be a good number of skilled operators when the present war is over.

Conclusion

The process so far has been utilized only where diving conditions are favorable. Since it is not practical for a diver to operate below a depth of 150 ft., there have been few attempts made to use the process on sunken ships much below this depth. There are many oil tankers with valuable cargoes which have been sunk in deeper water. Some device such as a diving bell probably could be designed for great depths. The diver would control from the inside mechanically operated cutting and welding torches. Such equipment would install valves, through which air could be pumped into the submerged ship from the surface. Another valve lower down would let the liquid cargo out through a pipe to another tanker at the surface. At the same time pumping could be controlled so as to refloat the ship. Any equipment which could carry out this work would have a large field of application.

Evidently then underwater cutting of metals is as fundamentally simple as surface cutting. By means of a gaseous globe the preheating medium is protected thus allowing the torch to give cutting performance. The gas torch is good on thick metals; the arch torch is good on thin metals. Thus the range of thickness covers almost any job that could be met. The successful operation of the torch depends more on the physical limitations placed on the diver than on difficulties with the torch itself. Thus the underwater conditions are of prime importance in considering the use of this process. Fortunately conditions seldom prevent cutting from being practicable.

Acknowledgments

I would like to take this opportunity to thank R. A. Dunn of the Canadian Liquid Air Co., Ltd., for information and criticism. For help received, I am indebted to W. E. Bonn of the Canadian Dredge and Dock Co., Ltd.; E. W. Shauffler of the Western Assurance Co., Ltd.; E. L. Mathy of the Victor Equipment Co., Ltd.; Charles Kandel of the Craftsweld Equipment Corp. and many others.

References

U. S. Submarine S-51, *Eng. News-Record* (New York), Aug. 5, p. 210 (1926).
Ellsberg, E., and Kandel, C., *Ibid.*, **118,** 373–375 (1937).
Kandel, C., *Ibid.*, **102,** 633 (1929).
Oxyacetylene Committee Publications, Section 1, *Oxyacetylene Cutting*, pp. 8–11.
Mathy, E. L., *Canadian Blacksmith*, March 1943, pp. 6–8.
Howard, R., *Scientific American*, **126,** 302–303 (1922).
Spraragen, W., and Claussen, G. E., THE WELDING JOURNAL, **19,** Research Suppl., 81-s to 96-s (1940).
Skerritt, R. G., *Compressed Air Magazine*, **38,** 4034–4038 (1933).
Schenstrom, William, *Canadian Machinery and Manufacturing News*, Jan. 6, pp. 27–44 (1927).
Welding Handbook, 1942 ed., Chapter 16D, pp. 715–719.
Kandel, C., *Weld. Engr.*, **14** (9), 65–67 (1929).
"Cutting Metals Under Water," *The Marine News*, March 1925.
"Cutting Cofferdam Piles at Riverbed Level," *Eng. News-Record*, Dec. 15, pp. 770–771 (1938).
Skerrett, R. G., *Compressed Air Magazine*, **48,** 7152–7159 (Oct. 1943).

APPENDIX I

Bibliography

Davis, R. H., *Deep Diving and Submarine Operations*, Saint Catherine Press London, pp. 169–176 (1935).
Autog. Metallb., **6,** 136 (1913).
Grafton, E., *Trans. South African Inst. Elec. Engrs.*, **21,** 186–190 (1930).
Trunschitz, *Autogen Schweisser*, **9,** 86–87 (1936).
Young, H. W., *Weld. Engr.*, **22** (3), 20–21 (1937).
Soudéur-Coupeur, **16** (1), 1–5 (1937).
Ind. Gases, **19,** 35–38 (1938).
Schimpke, P., and Horn, H. A., *Praktisches Handbuch der gesamten Schweisstechnik*, Vol. 1, 3rd ed., Springer, Berlin, pp. 262–264 (1938).
Ussher, A., *Weld. Engr.*, **21** (11), 20–25 (1936).
Soudéur-Coupeur, **16** (9), 34–41 (1937).
Hagglund, L. F., *Weld. Engr.*, **14** (1), 33–34 (1929).
Lebrun, M., *La Soudure Electrique a l'Arc*, L'Office Central de l'Acetylene, Paris, pp. 112–113 (1929).
Raymond, E. J., *Modern Engineer*, **8,** 37–38 (1934).
deJessey, L., *Cours d'Oxy-Coupage*, Institut de Soudure Autogene, Paris, 111 pp. (1938).
The Complete Welder, Vol. 1, G. Newness Ltd., London, pp. 341–358 (1939).
Kandel, C., *Welding Handbook*, 1938 ed., pp. 1148–1149
Polland, J. B., *Junior Instn. Engrs. Jnl.*, **35,** 224–242 (1924–25).
Welding Jnl. (London), **23,** 20–24 (1926).
Owens, J. W., *Fundamentals of Welding*, Penton Publ. Co., Cleveland, pp. 191–192 (1923).
U. S. Patent 1,981,766, G. Winckler, Nov. 20, 1934.

Metallic Arc-Welding Electrodes*

By Harold Lawrence†

Part I

CONFUSING indeed is the metallic arc-welding electrode situation unless one is familiar with the codes and identification systems designed to bring precise order out of a seeming state of chaos. Of course, once the details of the simple A.W.S.-A.S.T.M. (AMERICAN WELDING SOCIETY-American Society for Testing Materials) classification method are understood, the problem lends itself to ready solution. And adding to this a knowledge of the N.E.M.A. (National Electrical Manufacturers Association) two-color marking plan for heavily coated ferrous electrodes, the consumer begins to have an easy means for distinguishing between electrode types. The same information permits a direct comparison between the performance of the products of one manufacturer and those of another.

Consider A.W.S.-A.S.T.M. A 233 – 43 T which is formally described as Tentative Specifications for Iron and Steel Arc-Welding Electrodes. It discusses lightly covered and heavily coated metallic arc-welding electrodes for the welding of mild and low-alloy steels of weldable quality. In Table 1 are outlined the salient features of this specification with regard to the electrode classification number, the welding positions in which the electrodes may be applied, a general description that mentions the type of covering and the current and polarity with which it may be employed as well as physical properties for the stress-relieved and as-welded conditions.

What the Numbers Mean

Five major arrangements of electrodes in the heavily covered category are listed with tensile strengths ranging from 60,000 to 100,000 psi. Look at the E6010 group, for example, to see what the numbers signify. The first two numbers "60" refer to the minimum tensile strength in the stress-relieved state expressed in kips (thousands of pounds per square inch). The third number explains the possible welding positions such as "1" for all-position welding, i.e., flat, vertical, overhead and horizontal; or "2" which designates a greater restriction in choice by being usable in the horizontal fillet and flat positions only; whereas "3" in the third number indicates that these electrodes may be applied in the flat position alone.

The fourth number in the classification indicates subgroups and may be either "0," "1," "2" or "3" as things stand now. Thus, E6010, E6011, E6012 and E6013 are similar in two respects but differ greatly in the remaining characteristics. As the "60" in the first two digits shows, all four groups have a minimum strength of 60,000 psi. after stress relief; and as the "1" for the third digit suggests, any of the four groups may be chosen for all-position welding. But the differences pointed out by the several numbers in the fourth digit are quite important as subsequent articles in this series will demonstrate. (In the E10000 series the first three digits are used in the same manner as the first two digits in the lower strength groups.)

Since the classification scheme is built largely on factors connected with the mechanical properties of all-weld-metal tensile specimens, it is advisable to see how these specimens are prepared. Figure 1 shows the joint design and method of depositing the layers while Table 2 lists the controlling dimensions; $^1/_8$-in. electrodes being tested with a subsize, or 0.252-in. specimen. All of the larger diameters are tested with a standard 0.500-in. specimen; $^3/_{32}$-in. and smaller diameter electrodes are not tested for mechanical properties as those found for the $^1/_8$-in. size are considered to apply to the smaller diameters as well.

Although only a maximum limit on the thickness of each pass is shown, it is advisable to use no more than nine passes per inch of thickness for best results.

Factors Affecting Strength, Ductility

Technique is specified in detail because the relationship between strength and ductility in any weld is influenced greatly by interpass temperatures and cooling rates. In this connection it is possible that the interpass temperature of 212° F. suggested by the specification might be limited to the E45, E60 and E70 groups while an interpass temperature of about 400° F. would more closely

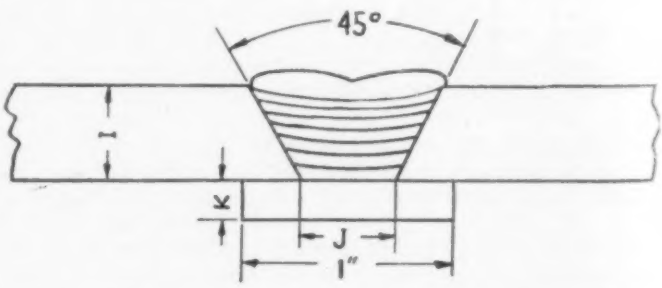


Fig. 1—Details of Joint Design for Determining Physical Properties of Weld Metal from Various Electrodes

* This series of articles has been presented by *Steel*, Cleveland, Ohio, in an effort to provide a working set of data which may be used as the basis for selecting the best electrode for any particular welding job. Every electrode group will be discussed in detail.

As a background for this review of the electrode picture for 1944, the main points in the applicable specifications will be discussed. It is suggested that every reader provide himself with copies of the available detailed specifications for metallic arc welding electrodes. These are A.W.S.-A.S.T.M. A 233-43T which may be secured from the American Welding Society, 33 W. 39th St., New York 18, N. Y., and N.E.M.A. publication 42-81 which may be obtained from the National Electrical Manufacturers Association, 155 East Forty-fourth Street, New York.

† Metallurgist and Welding Engineer.

TABLE I.—TENSILE REQUIREMENTS OF DEPOSITED METAL.

Electrode Classification Number	Capable of Producing Satisfactory Welds in Positions Shown[a]	General Description	Treatment of Welded Specimen[b]	Tension Test Requirements of Material Deposited from ¼ to 5/16-in. Electrodes[c]		
				Tensile Strength, min., psi.	Yield Point, min., psi.	Elongation in 2 in., min., per cent
E6010	F, V, OH, H	Heavy covering, useful with d.c., electrode positive only.	SR NSR	60 000 62 000	47 000 52 000	27 22
E6011	F, V, OH, H	Heavy covering, useful with a.c. only.	SR NSR	60 000 62 000	47 000 52 000	27 22
E6012	F, V, OH, H	Heavy covering, usually used with electrode negative, d.c. or on a.c.	SR NSR	60 000 62 000	47 000 52 000	22 17
E6013	F, V, OH, H	Heavy covering, usually used on a.c.	SR NSR	60 000 62 000	47 000 52 000	22 17
E6020	H-Fillets, F	Heavy covering, usually used with electrode negative or a.c. for fillets, and electrode positive or a.c. for flat welding.	SR NSR	60 000 62 000	47 000 52 000	30 25
E6030	F	Heavy covering, usually used with electrode positive on d.c., or with a.c.	SR NSR	60 000 62 000	47 000 52 000	30 25
E7010	F, V, OH, H	Heavy covering, useful with d.c., electrode positive only.	SR	70 000	57 000	22
E7011	F, V, OH, H	Heavy covering, useful with a.c. only.	SR	70 000	57 000	22
E7012	F, V, OH, H	Heavy covering, usually used with electrode negative, d.c. or on a.c.	SR	70 000	57 000	20
E7020	H-Fillets, F	Heavy covering, usually used with electrode negative or a.c. for fillets, or electrode positive or a.c. for flat welding.	SR	70 000	57 000	25
E7030	F	Heavy covering, usually used with electrode positive d.c., or with a.c.	SR	70 000	57 000	25
E8010	F, V, OH, H	Heavy covering, useful with d.c. electrode positive only.	SR	80 000	67 000	19
E8011	F, V, OH, H	Heavy covering, useful with a.c. only.	SR	80 000	67 000	19
E8012	F, V, OH, H	Heavy covering, usually used with electrode negative, d.c. or on a.c.	SR	80 000	67 000	17
E8020	H-Fillets, F	Heavy covering, usually used with electrode negative or a.c. for fillets, or electrode positive or a.c. for flat welding.	SR	80 000	67 000	22
E8030	F	Heavy covering, usually used with electrode positive d.c., or with a.c.	SR	80 000	67 000	22
E9010	F, V, OH, H	Heavy covering, useful with d.c. electrode positive only.	SR	90 000	77 000	18
E9011	F, V, OH, H	Heavy covering, useful with a.c. only.	SR	90 000	77 000	18
E9012	F, V, OH, H	Heavy covering, usually used with electrode negative, d.c. or on a.c.	SR	90 000	77 000	16
E9020	H-Fillets, F	Heavy covering, usually used with electrode negative or a.c. for fillets, or electrode positive or a.c. for flat welding.	SR	90 000	77 000	20
E9030	F	Heavy covering, usually used with electrode positive d.c., or with a.c.	SR	90 000	77 000	20
E10010	F, V, OH, H	Heavy covering, useful with d.c. electrode positive only.	SR	100 000	87 000	16
E10011	F, V, OH, H	Heavy covering, useful with a.c. only.	SR	100 000	87 000	16
E10012	F, V, OH, H	Heavy covering, usually used with electrode negative, d.c. or on a.c.	SR	100 000	87 000	14
E10020	H-Fillets, F	Heavy covering, usually used with electrode negative or a.c. for fillets, or electrode positive or a.c. for flat welding.	SR	100 000	87 000	18
E10030	F	Heavy covering, usually used with electrode positive d.c., or with a.c.	SR	100 000	87 000	18

[a] The abbreviations F, V, H, OH, and H-Fillets indicate welding positions, as follows:
F—Flat, H—Horizontal,
V—Vertical, OH—Overhead, and
H-Fillets—Horizontal Fillets.

[b] The abbreviations SR and NSR signify stress-relieved and non-stress-relieved, respectively. Stress-relieving when prescribed in these specifications is for the purpose of developing the fundamental properties of the weld metal unaltered by locked-up stress. Values obtained from stress-relieved welded specimens are about 5 per cent lower in tensile strength and 10 to 20 per cent higher in elongation than those of non-stress-relieved specimens. The fact that an electrode test requires stress-relief signifies only that it must develop the strength required regardless of stress-relief, and not that stress-relief must always be used in actual work. Stress-relieving shall be within the range of 1150 ± 25 F. for 1 hr. per inch of thickness. Specimens shall be heated in a suitable furnace at the rate of 300 to 350 F. per hour until a temperature of 1150 ± 25 F. has been attained. After this temperature has been reached, it shall be maintained for 1 hr. for each inch or fraction thereof of the maximum thickness of the section. The specimens shall be cooled at the same rate specified for heating and may be removed from the furnace when the temperature of the plates has reached 300 F.

[c] The tension test requirements of material deposited from 5/32-in. electrodes shall be the same as that indicated for 1/8 to 5/32-in. electrodes, except that the tensile strength and yield point shall be 95 per cent of that prescribed in Table I.

approximate field practice in the E80, E90 and E100 groups which are alloyed to give high tensile strengths.

Test plates are tacked together and preheated in boiling water before the first layer is deposited. After the first pass is made, the assembly, insulated from the welding bench by 1/2-in. of asbestos, is allowed to cool to a temperature below 212° F. before being placed in boiling water for another 5 min. This procedure is followed pass by pass until the final layer is deposited in two passes to complete the weld.*

Four types of plate material are specified: A.S.T.M. A7, A.S.T.M. A70, A.S.T.M. A203 (grade C) and A.S.T.M. A204 (grade C). The E45, E60 and E70 classifications are to be tested with the unalloyed base plate while the higher strength groups are to be tested with either the nickel or molybdenum alloy steels. All four steel types are shown in Table 3 where the essential data are given in a simplified and easily comparable form which differs slightly from the basic specifications.

It is unfortunate that this A.W.S.-A.S.T.M. specification for testing electrodes differs from the Navy procedure which suggests a steel quite similar to A.S.T.M. A204 for testing the E70 classification. *It is hoped that the two bodies can agree on a common test which would save all users of electrodes the time and money now wasted in a duplication of effort necessitated by minor differences in specifications.* The A.W.S. in attempting a unification of all codes and rules governing welding is taking a much needed step in the right direction.

A.W.S.-A.S.T.M. A[1] 233–43T also covers standard sizes and lengths. It is well known that small diameter electrodes overheat due to the resistance of the wire. This means a shorter length is needed. And a shorter length permits better control of the arc as well. Table 4 reports the standard lengths and it may be desirable to a point out deviations from these dimensions that will be found among various manufacturers' products.

* EDITORIAL NOTE: This immersion should not quench the assembly—the boiling water is intended as a preheat.

Many $^3/_{32}$-in. electrodes are available in 14-in. lengths only, while at least one manufacturer uses a standard length of 15 in. rather than 14 in. for his $^1/_8$, $^5/_{32}$ and $^3/_{16}$-in. diameter electrodes. As long as the operation permits the use of $^3/_{32}$ by 14-in. electrodes, this size will be more economical.

However, if 6-in. overheated stubs result, the shorter length is required, unless the long stubs may be set aside for later consumption. If this latter practice is attempted, the stub length should be great enough to prevent excessive overheating with its attendant destruction of certain coating attributes.

Dimensional standards are given in the specification, too. About 1 in. but no more than $1^1/_4$ in. of the electrode should be left bare for contact with the holder, while the other end should be sufficiently bare to allow easy striking of the arc. Most manufacturers brush the coating from the striking end of the electrode, leaving a bare portion which may be equal to the diameter of the core wire or $^1/_8$ in. whichever is smaller.

Table 2—Dimensions of Standard Test Plate for Determining All-Weld-Metal Properties of Arc-Welding Electrodes, in Inches

Electrode Diameter	Plate Thickness, I	Diameter of Tension Test Piece	Root Gap, J	Backing Bar, K
$^1/_8$	$^1/_2$	0.252 ± 0.005	$^1/_4$	$^3/_{16}$
$^5/_{32}$	$^3/_4$	0.500 ± 0.01	$^1/_2$	$^1/_4$
$^3/_{16}$	$^3/_4$	0.500 ± 0.01	$^1/_2$	$^1/_4$
$^7/_{32}$	$^3/_4$	0.500 ± 0.01	$^1/_2$	$^1/_4$
$^1/_4$	1	0.500 ± 0.01	$^1/_2$	$^1/_2$
$^5/_{16}$	$1^1/_4$	0.500 ± 0.01	$^1/_2$	$^1/_2$
$^3/_8$	$1^1/_2$	0.500 ± 0.01	$^1/_2$	$^1/_2$

The A.W.S.-A.S.T.M. specification places a limitation on the diameter of the core wire by saying that the diameter should not vary from that specified by more than ±0.002 in. This variation may be too great for a $^3/_{32}$-in. electrode while it surely is not objectionable for a $^3/_8$-in. electrode. A limit of ± $^1/_8$ in. is placed on the length of an electrode, although this control is of little practical importance beyond offering a check on the care with which an electrode maker regulates the physical dimensions of his product.

A means is suggested for measuring the concentricity of the coating. This is an important factor, yet no differentiation is made among electrode groups. Experience indicates that a degree of coating eccentricity that would be objectionable in an E6010 electrode would cause no trouble in an E6030 electrode. Electrical devices are available for testing coating concentricity without going through the tedious work of removing the coating. However, in the last analysis, coating distribution need not be investigated unless the coating is consumed unevenly, causing an uncontrollable arc. If the operator is certain that magnetic blow is not the culprit, the electrode should be checked for coating eccentricity. No more than 3% deviation from perfect concentricity is permitted.

Only two other coating characteristics are mentioned. First, the cool coating should possess enough electrical resistance to withstand a difference of potential of 100 v. Second, the slag produced shall be readily removable.

Both of these considerations are satisfied by almost all electrodes, although some of the more highly alloyed varieties may not withstand the resistance test. This possible shortcoming may be tolerated as long as the performance of the electrode is satisfactory when welding in a narrow groove. As for ease of slag removal, this matter is one that all electrode producers must keep foremost in mind when developing an electrode, for sales resistance would be great if the slag proved difficult to remove.

Core Wire Not a Problem

Under the heading of workmanship, several attributes of the core wire are discussed. It can be reported that the manufacturers appear to have this matter under control. Also under workmanship is the requirement that the coatings withstand normal handling without flaking and that they shall be of commercially uniform thickness. All electrodes withstand normal and often rough handling with the possible exception of stainless steel types where coating fragility is sometimes encountered.

Another requirement is that the coatings be free from injurious scabs, blisters, abnormal pockmarks, bruises or other surface defects such as cracks, etc. None of these shortcomings interfere with the arc unless they are flagrant violations of good manufacturing practice, with the possible exception of blisters. Where blisters result in an irregular consumption of coatings, the electrodes ought to be used on low-grade work only or should be scrapped.

Table 3—Types of Steel Used for Determining Physical Properties of Electrodes

Chemistry:	A.S.T.M. A7	A.S.T.M. A70	A.S.T.M. A203 (Grade C)	A.S.T.M A204 (Grade C)
Carbon, max., %	...	0.30	0.25	0.26
Manganese, max., %	...	0.80	0.80	0.90
Phosphorus,* max., %	0.04	0.04	0.04	0.04
Sulphur, max., %	0.05	0.05	0.05	0.05
Silicon, %	....	...	0.15–0.30	0.15–0.30
Nickel, %	...	...	2.00–2.75	...
Molybdenum, %	...	...	...	0.40–0.60
Physical Properties:				
Tensile strength psi.	60–72,000	55–65,000	75–87,000	75–87,000
Yield strength min., psi.	30,000	27,500	43,000	43,000
Elongation in 2 in., min., %	22	26	18	18

* Basic open hearth steel.

Marking is a factor that helps the average consumer to identify his material. The stamping or labeling of cartons is supposed to include the following information:

1. Classification.—This refers to the A.W.S.-A.S.T.M. classification number of the contents of each package. It is understood that the manufacturer has tested his products and is able to guarantee physical properties when the conditions of test mentioned earlier have been met.

2. Manufacturer's Name and Trade Designation.—Of course this means the name of the producer and his name for the particular electrode. It is this latter name that causes most of the confusion in the welding industry. There are those who claim with righteous indignation that electrode names are not as meaningful as Pullman car names. For this reason the classification number ought to be shown in *large* type.

3. Standard Size and Length.—This refers to the diameter of the core and the length of the core. In the case of reels and coils, the diameter of the core and total weight is shown.

4. Guarantee.—This is generally covered by giving the classification number although some brands also report

the various specifications met by the electrodes in each package. Other producers show this information, which may be too voluminous for box end or label, in their catalogs.

5. *End-Tipping.*—The A.W.S.-A.S.T.M. specification as now set up does not cover this point. N.E.M.A. does and the data for several classification groups and an explanation of the scheme follow.

Table 4—Standard Sizes and Lengths of Arc-Welding Electrodes, in Inches

Diameter of Core Wire	Standard Lengths
1/16	9 or 18*
5/32	12 or 18*
1/8 and 5/32	14
3/16	14 or 18
7/32, 1/4, 5/16 and 3/8	18

* 1/16 and 5/32 x 18 sizes require center gripping. All other lengths require end gripping.

Metallic arc-welding electrodes are dressed up in coatings that exhibit every hue in the rainbow. Some of these coatings show natural colors brought about by the pigmenting effect of the coating constituents. Thus E6010 electrodes may be white because of the fine particles of titanium oxide (TiO_2) in the formula. Frequently E6012 electrodes are tan because of the coloring

Table 5—N.E.M.A. Two-Color Markings for Common A.W.S.-A.S.T.M. Electrode Classifications

A.W.S.-A.S.T.M. Electrode Classification Number	End or Primary Color	Spot or Secondary Color
E6010	None	None
E6011	None	Blue
E6012	None	White
E6013	None	Brown
E6020	Blue	None
E6030	White	None
E7010	None	Green
E7011	None	Red
E7020	Blue	Green

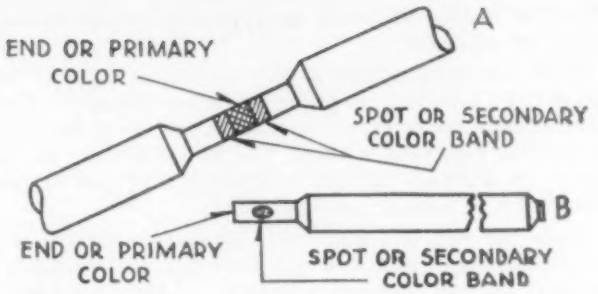


Fig. 2—N.E.M.A. Two-Color Markings for Center-Grip Electrodes Shown at *A*, and for End-Grip Electrodes Shown at *B*. The Secondary Color May Be Either a Narrow Band or a Spot

influence of the rutile that constitutes a large percentage of the coating. Or E6030 electrodes may be red or brown or black depending upon the kind of iron oxide found in their formulas.

Electrode purveyors also put dyes and pigments in their coatings to further influence the colors. Thus we find blue, pink, green and orange colors introduced to distinguish different brands. And one producer goes further by placing identifying dots on the coating of his electrodes to separate his brand from other brands.

To bring a decent degree of order into this situation, N.E.M.A. has devised and agreed upon a two-color system of electrode identification. It depends upon an end or primary color and a spot or secondary color as shown in Fig. 2. Table 5 develops the colors used for nine popular electrode classifications. Not all makers of electrodes are using this system but every day sees more of them adopting it and 1944 ought to see the plan in almost universal application.

So much for the fundamental information necessary to demonstrate how electrodes may be classified. Almost all present brands are good and may be used with confidence. However, there are differences between makes which might be compared to the differences among Chevrolets, Fords and Plymouths in the automotive field. In addition, there is the matter of engineering service that further influences electrode choice. In coming articles in this series, details of applications for each classification in popular use will be presented.

Part II—Class E6010 Electrodes

ALMOST three-fourths of all the millions of pounds of metallic arc-welding electrodes used fall into the A.W.S.-A.S.T.M. E6010 classification. And as might be surmised from the foregoing statement, E6010 electrodes possess some outstanding properties that make them particularly suitable for a wide variety of welded joints. Although there is no such thing as a universal electrode, Class E6010 comes the closest of all available types to filling this role.

Notwithstanding the publicity that has been given the A.W.S.-A.S.T.M. classification method, engineers are still unfamiliar with electrodes when only the type numbers are given. Likewise there is the question of interchangeability. Is such and such an electrode like so and so?*

Of course, these are all coated electrodes. They are well adapted to welding in all positions—flat, vertical, horizontal and overhead. Generally this class of electrode is used in the vertical and overhead positions where no other type gives better physical properties or X-ray soundness.

A penetrating arc is a characteristic of E6010 electrodes. This factor insures good root penetration when fillet welds are being made. Or this attribute may be needed in butt welds when deep penetration is required as in a single-V weld. Or for that matter, penetration is most desirable in tack welding where these electrodes are used more than 90% of the time.

Weld metal produced by this group of electrodes solidifies quickly. This property explains the good welds that are found in the vertical and overhead positions where the deposit is flat. In fact the E6010 and E6011 electrodes are classified by one electrode producer as groups that deposit flat fillet welds. That is, these welds possess neither excessive convexity nor excessive concavity, being for all intents and purposes of flat contour along

* To clarify this point and to provide a rather complete list of available electrode products *Steel* in its publication listed 23 suppliers of E6010 electrodes.

the face of the fillet. The same quick-setting property helps the welder to avoid undercutting which detracts from joint efficiency.

E6010 electrodes form a very desirable type of slag which has a low melting point and a low density. These features combine to permit oscillation, weaving and whipping of the electrode without the danger of slag entrapment. In addition the low volume of slag that is made contributes to ease of manipulation.

While the slag provides some protection for the weld metal, the major share of the essential arc shielding is assumed by the gaseous envelope. Large volumes of hydrogen, carbon monoxide, water vapor and carbon dioxide are evolved as the coating burns. One volume of coating gives off more than 300 volumes of gas. As the gas forms and spreads out from the arc, the harmful gases from the atmosphere, oxygen and nitrogen, are kept away from the weld metal.

It is claimed that the gases generated by the burning coating establish the polarity of this electrode group. At any rate the E6010 type is useful with direct current only. Furthermore, good results may be obtained with reverse polarity alone. When reversed polarity is spoken of, the electrode is positive and the work negative. With the circuit arranged for straight polarity the electrode is negative and the work is positive.

The electrodes under discussion are often referred to as cellulosic. No doubt the reference arises from the substantial amount of cellulose found in the coating. Besides the cellulose, the major gas-forming constituent, will be found slag-forming materials such as titanium dioxide and magnesium or aluminum silicates. Some ferromanganese is added to function as a deoxidizer or degasifier. These four or five ingredients are stuck together and glued to the core wire with sodium silicate.

The core wire itself is a rimmed steel containing from 0.10 to 0.15% carbon, some 0.40 to 0.60% manganese and small amounts of phosphorus and sulphur as impurities. Of course, varying degrees of performance are exhibited by different brands and the consistency of the final product is a measure of the skill and care with which the manufacturing operation is controlled.

This group of electrodes deposits a low-carbon steel weld metal. Manufacturers' literature reveals the ranges reported in Table 6. Quite a spread is shown for

Table 6—Deposit Analyses Produced by E6010 Electrodes

	C	Mn	P	S	Si	Cu
Min., %	0.05	0.25	...	...	0.02	..
Max., %	0.12	0.60	0.040	0.040	0.30	0.12

manganese and silicon which may be a matter to be questioned as it is doubted that such low values as the lower limits reported will permit satisfactory physical properties.

Speaking of physical properties, the excellent values to be found are shown in Table 7. The yield point, ultimate strength and elongation are reported for the stress-relieved and nonstress-relieved conditions while no data were given for heat treatment with regard to the remaining properties. Table 7 confirms the observation frequently made that lower strength is found after stress relieving while high ductility results from the heat-treating cycle. In connection with the ductility values given in Table 7, it must be reported that some makers listed values of 20% minimum elongation in 2 in. for the nonstress-relieved specimens. In view of the minimum requirement of 22% given by the controlling specification

Table 7—Physical Properties of Deposits Made with E6010 Electrodes

Property	Stress-Relieved	Nonstress-Relieved
Yield point, psi.	47–56,000	52–66,000
Ultimate strength, psi.	60–72,000	62–80,000
Elongation, % in 2 in.	27–37	22–33
Izod impact strength, ft.-lb.	30–70	
Brinell hardness	140–160	
Density, gm./cc.	7.82–7.86	
Endurance limit, psi.	28–32,000	

for this state, it was assumed that the lower values were shown in error.

Ranges in current and voltage were outlined in several instances and are available for reference in Table 8. Once again there is evidence that a wide spread has been chosen. In actual welding practice, the extremes of the ranges are not workable. Since E6010 electrodes are not noted for a stable arc at low currents, the lower amperages

Table 8—Current and Voltage Ranges for E6010 Electrode Applications

Size of Electrode, In.	Recommended Amperes	Recommended Volts
3/32	20– 80	18–25
1/8	70–150	22–28
5/32	90–200	24–30
3/16	130–350	24–36
7/32	160–400	25–38
1/4	175–500	25–40
5/16	250–625	31–42
3/8	300–750	32–45

will lead to sticking of the electrode and a certain amount of deposited metal that is below par. The higher current limits may introduce a different trouble. After all, cellulose is similar to paper and everyone knows what happens to paper when it is overheated. It chars. At high amperages the cellulose in the electrode coating behaves the same way. Charred cellulose frequently leads to surface holes or pits in the deposited weld layer.

Some comments about the voltage ranges may be worth while. Here, too, the difference between the lower and upper limit is appreciable. Voltage usually increases with increasing thickness of coating. Voltage is greater with higher water contents, provided that the water is held in the coating during welding. Or high voltage may come from an irregular consumption of the coating resulting from magnetic disturbances or uneven distribution of the coating around the core.

One clue to the applications of the E6010 classification of electrodes may be found from the list of approvals reported by the different manufacturers. These data reveal that these electrodes meet the requirements of the following bodies:

Air Corps Specification No. 10286-B, Grade 6-E.
American Bureau of Shipping, Hull Class 1 and Boiler Class 1, all positions.
A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels, Paragraph W-520.
A.S.M.E. Code for Unfired Pressure Vessels, Paragraphs U68, U69 and U70.
Bureau of Ships Specification 46E3 (INT), Grade I, Classes 1, 2, 3.
Department of Commerce, Bureau of Marine Inspection and Navigation.
Hartford Steam Boiler Inspection and Insurance Co.

Lloyds Register of Shipping, Section 4, Paragraphs 1–9.
United States Coast Guard, Merchant Marine Inspection.

No further proof should be needed to demonstrate the ability of this electrode group to satisfy exacting quality demands.

Unchallenged in Shipbuilding

The best way to establish the true character of the E6010 electrode classification is to consider the work being done with these electrodes today. Unchallenged in the shipbuilding field, this electrode type has made possible the bridge of ships that maintains our fighting men the world over. For the shipbuilding industry employs unique constructional features for which the cellulosic electrodes are eminently well suited.

Basically a ship is a combination of steel plates of varying thickness that might be compared to a skin attached to a rugged skeleton of stiffeners of structural steel. This set of conditions is conducive to tacking large subassemblies which are later fitted into place in the ship. E6010 electrodes are used for the tack welding and later are pressed into service for the seam welding. Because the subassemblies are quite large, there is no opportunity to position the work for downhand welding. Since the service for which ships are designed is severe from the standpoint of stresses, the best in weld quality is necessary. Fortunately the E6010 electrode group functions well by taking each joint in whatever position it is found and by stitching the parts together with metal of unquestioned quality.

Most shipyards requisition more than half their electrodes in the E6010 grade with the remainder of their needs coming from the E6012 and E6020 types. Most popular sizes are the $^{5}/_{32}$ and $^{3}/_{16}$ in. which account for about 80% of shipyard consumption with $^{1}/_{8}$ in. taking up about another 10%, the remainder coming in the other diameters.

Every type of ship from submarine to aircraft carrier is fabricated with the cellulose or organic electrode. All important tack welds are made with the same rod type and the finishing welds of landing craft, tankers, barges, tugs and the myriad other vessels are largely fashioned from this same class.

Although the shipbuilding industry is the largest construction activity that depends upon the all-position cellulosic electrode, there are many other important fields, such as in the realm of piping. Thousands of feet of prefabricated piping will be found in ships and factories; at the same time pipe lines rush *black gold* from Texas to the Atlantic Coast—with E6010 welds holding the many lengths together in one continuous line.

But why is the E6010 electrode so popular for pipe work? The answer lies in the combination of penetrating arc with quick-setting properties in the weld metal. For piping is joined with single-V or U-butt joints, sometimes with and oftentimes without a backing strip, that must be sound and strong. Although some pipe may be rolled to permit flat-position welding, most of it must be connected in the vertical or horizontal fixed positions. It is this latter condition that makes the all-position electrode mandatory.

Repairs Equipment in Battle Areas

Pressure vessels do not provide much welding for the cellulose electrodes because they are largely shop built and can be rolled or set to permit the bulk of the welding to be done in the downhand or flat position. However, these units are always tacked together with E6010 electrodes and many fittings and attachments are made with the same group of electrodes.

The contribution of the pressure vessel industry to high-test gasoline and synthetic rubber gave a big boost to our war production. Much field erection and many welds in the field were needed to get the new war plants into operation Of course thousands of these welds were in the vertical, overhead and horizontal positions. And naturally the E6010 electrodes did the job.

Our Army engineers and the Navy's Seabees have accomplished incredible feats of engineering work in the battle areas. Much credit belongs to our rugged road building and earth moving machinery. But this equipment, because of long work schedules without a breathing space, has often been damaged or broken. But seldom has the trouble stumped the service welder with his handy pouch of E6010 electrodes.

Unusual truck bodies and chassis have been ordered on short notice. Very often a limited number were needed for a special service or for trials under unusual field conditions. Flame cutting and welding with organic electrodes did the job . . . and quickly.

Notwithstanding the tremendous number of welds made by the aircraft industry, there is surprisingly little completed with E6010 electrodes. In this work the E6013 and E6012 which will be treated in later articles have turned out to be the best types. But mass production in the aircraft industry did not signify any deviation from the close tolerances that always prevailed. On the other hand, thousands of jigs and fixtures for setup and actual welding were fabricated with all-position electrodes to develop the ruggedness necessary to a combined jig and strongback.

One worry connected with organic electrodes has been the fact that they are a perishable product. How perishable no one knows with certainty. But all electrodes of this class absorb moisture from the surrounding humid atmosphere. Dryness tests will quickly demonstrate this fact.

To overcome absorbed moisture, many electrode users have constructed heated cabinets. Equipment of this sort appears to be worth while although several manufacturers of electrodes caution against overdrying their material when using this method.

The ideal electrode storage, used by many shipyards, is an air-conditioned room where both temperature and humidity are controlled. However, this solution to the problem is too costly for the average user of such coated electrodes.

A better plan appears to be a proper planning of inventories to avoid long storage periods. If electrodes, like coffee, are perishable, why not keep a fresh supply on hand?

Almost a Universal Electrode

Some moisture is desirable in E6010 electrode coatings. Too dry a coating leads to unsatisfactory welds. A dry coating in the hands of an inexperienced welder means many surface porosities. Nor is a wet coating desirable. All too often wet coatings are associated with uneven arc performance and puffing of the coating. Fresh stocks and some slight heating before use may be the answer. Perhaps before too long the makers of electrodes can report factual data on the effect of absorbed moisture.

This report has presented a bird's-eye view of the E6010 electrode and its applications. It is a quality product and were all other types to disappear, no welded joint would vanish. In other words it is a close approach to the universal electrode. It has good points and it has

bad points. Welds produced with this type of electrode are good but not perfect. Some small porosity will be recognized by the X-ray.

Another type gives more ductility. Yet another gives more strength. A third one is faster. Another type is colder. And so on. But succeeding articles in this series will tell of the other types and this one fact remains: Almost three-fourths of all the millions of pounds of metallic arc-welding electrodes that are used fall into the A.W.S.-A.S.T.M. E6010 classification.

Part III—Class E-6011 Electrodes

A REVIEW of the Class E6011 electrodes is somewhat handicapped by sales optimism. Many distributors of metallic arc-welding electrodes try to cover as many types as possible. This situation is understandable as no salesman enjoys sending a prospective customer to a competitor except as a last resort. But for someone attempting to understand the place of each electrode type in some logical pattern, the tendency of manufacturers to make products suitable for two or three grades renders the whole matter confusing.

Basically the E6011 electrode is a first cousin of the E6010 electrode. The former works well with alternating current while the latter is restricted to direct current, reverse polarity. Otherwise either grade, when used with the right current and polarity, can do precisely the same work as the other.

Where does disorder enter this picture? Right here. An electrode that could be used with direct current or with alternating current to do exactly the kind of welding for which the E6010 electrode has achieved a well-deserved popularity would be a distinct possibility. If the article on E6010 electrodes is compared with this one, it may be noted that one manufacturer has done this very thing. But several manufacturers report a combined grade E6011-grade E6013 electrode. This situation may be something of a paradox.

The A.W.S.-A.S.T.M. classification system gives different ductility requirements for these two classes; that is, E6011 electrodes must produce weld metal with a minimum elongation of 22% the nonstress-relieved condition, whereas the E6013 electrodes need meet a minimum elongation of but 17% in the same state. Of course an electrode that meets a specification demand of 22%, also satisfies 17%. Perhaps it is this situation that has led some electrode makers to report an E6011-E6013 electrode.

However, the difference is intended to cover more than physical properties. As is shown in Fig. 3, fillet contours are a function of electrode classification type. Since the E6013 electrode is "colder" than the E6011, the fillet bead is decidedly convex instead of flat. Since the E6013 electrode is "colder" than the E6011, its deposit contains more porosity. But that's enough data to suggest that the E6013 electrode is intended to be different from the E6011. As will be shown in a later article, the E6013 electrode will perform some functions that are outside the capabilities of the E6011 variety.

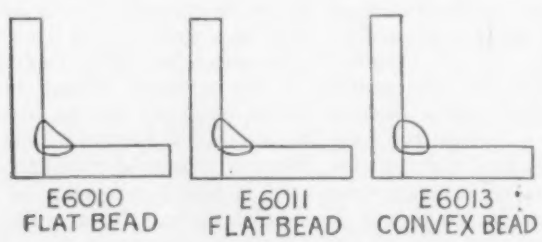


Fig. 3—Fillet Contours Produced by Different Grades or Classes of Arc-Welding Electrodes

Please remember that some regard this as a controversial subject, which would suggest that the reader may wish to make some tests in his own plant. Before leaving this idea, some discussion of electrode design may prove helpful. Electrodes are designed by men who have rather definite notions of what they desire in the final product. They consider several dozen attributes among which are ease of handling, quality of bead, chemistry, slag, spatter, appearance, soundness penetration, etc. So it is not surprising that the electrode that emerges from the laboratory is definitely a compromise. Because several raw materials have been balanced with methods of manufacture, the product of one producer is bound to be different from that of another.

Likewise a compromise between E6011 and E6013 classes possessing the physical properties of the former can be brought about. Yet welding is something like playing a violin. The right notes can be played by many players. But the feeling of the music, that certain quality that electrifies an audience, is reserved for a few musical geniuses. So it is with electrodes. Good welds may be made with any number of electrodes but the best and cheapest welds will result when a perfect matching of electrode grade and welded joint has been brought about. In this day when every industrialist is thinking of trimming costs for the days of free competition that are ahead, there is a premium on sensible selection of electrode classes.

Whereas there were 23 producers of E6010 electrodes, there are but 12 makers of the E6011 class.* When you recall that E6010 electrodes have been in the market for many years before the development of the E6011 type (first announced in 1942), the disparity between the two lists is understandable.

Very likely the sale of E6011 electrodes does not exceed 5% of the total electrode production. Still in the scant two years since its inception, many applications have been discovered where no other type works quite as well. Coincidental with the development of this distinct electrode class has been the expansion of the use of a.-c. (alternating current) welding.

Although a.-c. welding was used during the first World War, it fell into disuse because of the need for high open-circuit voltages and because of the lack of suitable electrodes. About 1936 a.-c. welding began a comeback which continued at an accelerated rate during this war and which promises to continue after the war.

Undoubtedly the main reason for the popularity of a.-c. welding is found in the greatly lessened effect of magnetic disturbances found with direct-current welding. These interferences, usually called "magnetic or arc blow," interfere with the deposition of sound weld metal. At times magnetic blow assumes proportions that almost prevent the making of any weld at all. With experience a welder learns to outwit this devilish condition but not without using up much more energy than would be devoted to making the same weld were no magnetic blow there. Similarly the use of alternating current has enabled the beginners to turn a much needed hand to pro-

* *Steel* published list of manufacturers of these electrodes.

duction welding without the weld cut-outs that excessive blow would have necessitated.

E6011 electrodes are heavily coated, 10 to 15% of the electrode weight is coating, designed to lay quality weld metal in the flat, vertical, horizontal and overhead positions. They, like the E6010 class, are commonly known as all-position electrodes. For the highest quality work that is done in the vertical and overhead positions with alternating current, E6011 electrodes are the right choice. Deposited metal is sound enough to pass X-ray examination.

A digging arc characterizes E6011 electrodes and leads to good penetration in fillet welds. Single V-butt welds need this penetration too. Also tack welding provides a good outlet for a digging arc and good physical properties. Gapped seams where penetration is of utmost importance are best welded with the E6011 electrode because this application is frequently troubled with magnetic blow.

More Slag—Less Gas

Slag characteristics of E6011 electrodes are like those of E6010 with some exceptions. The slag possesses both a low melting point and a low density. Such physical attributes allow the complex manipulation associated with some vertical and overhead welding operations. Although the volume of slag would be considered as low, there is more slag present than would be encountered with the E6010 group.

Arc shielding is largely accomplished by the gases driven out of the coating as the electrode is consumed. The function of this gas shielding is quite similar to that discussed for E6010 electrodes. However, there is more slag with the E6011 group and conversely less gas. Although this type is definitely in the gas-shielded category, it leans more to the mineral coated composition than does the direct current, reverse polarity, cellulosic electrode of class E6010.

Primary coating constituents are cellulose, asbestos, titanium dioxide, ferromanganese and an alkaline arc stabilizer. Cellulose furnishes the gas so essential to a gas-shielded electrode and is responsible for the carbon monoxide, hydrogen, water vapor and carbon monoxide found in the protecting atmosphere.

The asbestos provides a slag with the aid of the titanium dioxide which also serves to stabilize the arc. As usual the ferromanganese acts as a deoxidant and may help to make the slag more friable. All of these materials were found in the E6010 coatings but now a new material is added.

A.-c. electrodes must overcome a hurdle that is not encountered in d.-c. welding. For the alternations of the current with both voltage and amperage fading away to zero many times a second place an extra value on arc stability. In the E6011 electrode all of the peculiar conditions associated with high-quality welding in all positions must be satisfied while providing *an extra measure of arc stability*. Alkaline compounds of sodium and potassium, more often the latter, furnish a means of attaining good arc performance with alternating current.

Fundamentally, though, the E6011 electrode behaves quite like the E6010. Its performance with alternating current is acceptable for the end use intended. No other electrode will behave on alternating current to show qualities found in the E6011 group. But the arc action leaves a great deal to be desired.

Standardize on E6010

As might be suspected these electrodes may be used with direct current as well as with alternating current. Nor is it too strange to discover that reverse polarity arc performance is more satisfactory than that with straight polarity. Moreover, either type of current and either polarity will lead to equally satisfactory physical properties. But E6011 electrodes are not recommended for d.-c. welding. *Better standardize on the E6010 for direct current and pocket the difference as the latter are cheaper.*

E6011 electrodes produce a weld metal that falls into a low-carbon pattern. Values reported by the different manufacturers have been gathered together and are summarized in Table 9. Once again an examination of the ranges shown leads to the conclusion that the spread for manganese and silicon is greater than can be explained by the physical properties. Manganese ought to run from 0.25 to 0.60 and silicon ought to be at least 0.10 if strengths are to be above the minimum requirement.

Table 9—Deposit Analyses Produced by E6011 Electrodes

	C	Mn	P	S	Si	Mo	Ni	Cu
Min., %	0.07	0.21	...	...	0.05	...	...	...
Max., %	0.12	0.60	0.04	0.04	0.25	0.025	0.025	0.12

Table 10—Physical Properties of Deposits Made with E6011 Electrodes

Property	Stress-Relieved	Not Stress Relieved
Yield point, psi.	47–56,000	52–61,000
Ultimate strength, psi.	60–68,000	62–71,000
Elongation, % in 2 in.	27–33	22–27

Physical properties are reported in Table 10 with all of the values having been gleaned from manufacturers' catalogs. Some ductility values were listed at figures below the minimum value specified for E6011 electrode and the minimum figure is shown in Table 10 as it was suspected that this is the value to be expected.

Ranges for current and voltage to be used with each diameter of electrode are given in Table 11. Here it may be noted that the spread is nowhere near as great as was listed for E6010 electrodes. This state of affairs is no accident. One notable requirement of E6011 electrodes is that they be used within a narrow range of current. Overheating leads to inferior physical properties. Similarly strange mechanical properties will be found when insufficient current is selected.

Table 11—Current and Voltage Ranges for E6011 Electrode Applications

Size of Electrode, In.	Recommended Amperes	Recommended Volts
3/32	25– 85	17–29
1/8	85–135	21–29
5/32	115–185	22–26
3/16	150–235	24–26
7/32	165–280	25–27
1/4	225–315	26–28

This point might be kept in mind should any difficulty be encountered in passing physical tests imposed by welding codes. In fact, while it is a good idea to follow manufacturers' suggested values with all electrodes, it is almost mandatory that you do so with E6011 electrodes.

Because the E6011 electrodes are rather new, not all of the possible approvals have been secured. A smaller list than was shown for E6010 electrodes is the result, although it is to be expected that E6011 electrodes will

eventually qualify everywhere that E6010 have been accepted. At any rate the following codes and specifications have been met:

American Bureau of Shipping, Hull Class 1 and Boiler Class 1.
A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels, Paragraph W-520.
A.S.M.E. Code for Unfired Pressure Vessels, Paragraphs U68, U69 and U70.
Bureau of Ships Specification 46E3 (INT), Grade III, Class 1.

Although E6011 electrodes were developed with the specific needs of the shipbuilding industry in mind, the shipyards have not turned to this group in all cases. The explanation will be found in the current generating conditions in the various yards. While some of the newer yards are well equipped for a.-c. welding, most of the older yards are set up for d.-c. welding.

Along the ways, especially, the older yards are accustomed to providing constant-potential generator outlets. A hundred or more welders take their current from resistance boxes along the feeders from a centrally located constant-potential generator of 1500 amperes minimum capacity. Since all of the welders are seldom welding at the same time, this is a most economical way of getting welding current. Besides these large generators have a high power factor which is often helpful in offsetting a less favorable power condition from other power-driven machinery about the yard.

One drawback to the constant-potential generator is the restriction of one polarity. All of the welders must use electrodes that work with direct current, reverse polarity. However, this is no hardship as most of the work is done with E6010 electrodes anyway.

The newer yards are experiencing the advantages of alternating current on the ways and in their shops. Older yards, too, are using alternating current for shop fabrication. Freedom from magnetic blow and more footage per day offset the slightly higher price of the E6011 group.

Some piping is now being welded together with E6011 electrodes. All of the advantages already discovered for the E6010 electrodes have been resurveyed with the E6011 group. Piping often has fit-up that leaves a gap where magnetic currents are bothersome, but the a.-c. electrode leaves the operator free to concentrate on his work without any need to fight arc blow.

Small pressure vessels having a $^1/_4$- or $^5/_{16}$-in. wall are being fabricated with E6011 electrodes. Good practice suggests welding such units with a gapped seam so as to minimize the chipping to sound metal demanded by the A.P.I.-A.S.M.E. and A.S.M.E. codes. But with direct current, magnetic blow always spells irregular penetration. Not so with E6011 electrodes and alternating current. This combination guarantees uniform penetration from end to end of the longitudinal seams and makes chipping remarkably easy.

Air-Conditioned Storage Ideal

Exposure to humid atmospheres is troublesome when E6011 electrode storage is considered. To a possibly greater extent than is the case with E6010 electrodes, these coatings are hygroscopic. Very often an increased moisture content is reflected in a poorer arc section. Spatter may be greater as a result of more moisture. And the physical properties of the weld metal can be adversely affected.

Air-conditioned storage is ideal while a dry, warm storage room is next best choice. Heated cabinets can be used to advantage if the temperature is kept low enough, certainly not over 200° F. Even at this seemingly low temperature, storage ought to be restricted to a maximum of about 2 hr.

E6011 electrodes are the universal electrodes with alternating current. They are new, yes, but it is conceivable that all welding jobs might be done with them. Considering the fact that an organic electrode can be used with success on alternating current, it is clear that welding has come a long way during the war.

Some day E6011 might offer E6010 electrodes a good run for their money. In situations where magnetic blow is pestiferous, alternating current works wonders. Production speeds are high when the welder is free to deposit his beads with a minimum of disturbance. In the E6011 electrode is found a tool that advances the science of welding to one further degree of engineering refinement in the field of mass production where Americans shine.

Part IV—Class E6012 Electrodes

BOTH the E6010 and the E6011 electrode types previously discussed deposited the highest quality weld metal for all-position welding. E6010, a d.-c. reverse-polarity electrode, and E6011, its a.-c. counterpart, were designed to satisfy the specifications of the Bureau of Ships. In this description of weld deposit qualities, the best possible values of strength and ductility were outlined. Rightly enough, the Navy has always been a stickler for outstanding physical properties in its *materiel*.

But a need was early recognized among welding fabricators for a different type of electrode. The harsh, digging arc of the E6010 electrode was all right in many places. But the old timers felt that bare wire welding had offered some advantages not to be found with the heavily coated cellulosic product. A "colder" deposit would be mighty useful here and there.

So the welding electrode manufacturers back-tracked a little. From the laboratory came a "cold" electrode. Like bare wire it worked best with direct current, straight polarity. Like bare wire, it was "cold" and built up a high, even bead. Like bare wire, it had to be operated with a short arc. *But unlike bare wire, it was a coated electrode and possessed good physical properties.*

E6012 electrodes, excellent coated electrodes exhibiting the good functions of bare electrodes, have been called "poor fit-up" or "general purpose" electrodes. In fact, 3 of the 23 manufacturers of this type have symbols or names to support this contention. Harnischfeger's "PF" very likely stands for poor fit-up; Westinghouse's "FP" could be fit-up poor; and Metal & Thermit's "genex" suggests general purpose.

As usual, the rest of the names give no clue as to their intended application. Thus the existence of the A.W.S.-A.S.T.M. classification system described in Part I of this article, proves to be quite valuable. Likewise the existence of the N.E.M.A. two-color identification plan discussed in the same part will tend to force the producers of arc-welding electrodes to select the one A.W.S.-A.S.T.M. classification for which their product is best

suited instead of attempting to cover several types with a single electrode as has been done in the past. All of these standardization programs serve to make a rather complex subject readily understandable to the users of electrodes.

Getting back to the terms "poor fit-up" and "general purpose" for a moment, what is the meaning of these expressions? Poor fit-up means just what it describes. All too often, more so in the past than today, wide gaps will be found in structures that have been tacked together preparatory to welding. These gaps must be bridged. But welding along an unsupported edge, particularly in relatively thin steel, is troublesome because most electrodes under these circumstances will melt away as much metal as they deposit. The E6012 electrode is a notable exception and has been widely applied to structures where fit-up has been poor. The "cold," molasses-like weld metal coupled with a shallow penetrating arc works wonders in what would otherwise be a trying situation.

The term "cold" is applied because the molten metal from the rod is stiff and of high consistency. It acts like the molten metal was "colder" in that it does not run or flow freely.

As for the words "general purpose," they mean what they say. Every maintenance department in a large plant has learned to rely on E6012 electrodes for a wide variety of welding jobs. A new safety guard is needed for an exposed portion of a moving machine. In a jiffy the maintenance department welds up a protective screen with the general-purpose electrodes. Or a new attachment is needed. The part is fabricated and welded in place, flat, vertical, overhead or horizontal, it makes no difference to the all-position general-purpose electrode.

E6012 electrodes are *fast*. Production work goes very rapidly when this type of electrode can be used. Although the as-welded elongation in 2 in. for E6012 electrodes is but 17% minimum while the E6010 and E6011 types exceed 22%, there are hundreds of thousands of applications where no more than 17% elongation is needed. For this work the many advantages of the E6012 electrode must not be overlooked.

There is little spatter from E6012 electrodes. Careful tests have disclosed that there is less spatter from this group than from any of the other electrodes in the E60xx bracket. Actual data reveal from 4 to 8% of the core lost as spatter from the best electrodes in the E60xx classification. About 6 to 12% is lost with E6010 electrodes whereas from 8 to 15% may be lost with the E6011 product. Spatter is worth considering because many jobs must be painted after welding. If little spatter accompanies the welding, not much cleaning need be done before painting.

Frequently the steel alongside the joints to be welded is protected with a compound that prevents the spatter from sticking. Preparations of this sort allow the light spatter from E6012 electrodes to be removed with a wire brush either manually or mechanically driven. *This point might well be filed along with other suggestions for cutting costs in connection with the manufacture of postwar products that must sell for a price in a highly competitive market.*

Wherever single-pass horizontal fillets are specified, E6012 electrodes ought to be used. Of course some specifications demand a different class of weld metal. But every weld that is not governed by limiting specification ought to be done with the E6012 group. Without a shadow of a doubt the best appearing horizontal fillets are made with this electrode. There is no undercut; there is almost no spatter; and the slag, once it has cooled, separates cleanly.

In addition large diameter electrodes at high currents and fast rates of travel are most satisfactory. Nowhere else can $^5/_{16}$-in. electrodes be used with $^1/_4$-in. steel plates to produce an acceptable weld. Naturally this is an extreme example. Yet more than one production superintendent has been amazed at the labor savings made possible by an intelligent matching of the E6012 type of electrode with the many jobs for which it is well adapted.

Shop fabrication of structural steel is another use to which E6012 electrodes are put. Here, too, the economy of an electrode that can withstand high currents when welding light sections is appreciated. Another advantage comes from the fact that unskilled welders can work with E6012 electrodes turning out good quality work while gaining the confidence and experience so essential in a welder's make-up.

This group of electrodes, as originally developed, operates to best advantage with direct current, straight polarity. Wherever the welding conditions permit, this combination of current and polarity ought to be used. If magnetic blow is not a factor, and there are welded joints where blow is nonexistent, direct current with straight polarity will deposit the greatest amount of weld metal of any possible combination of current and polarity. With the same number of amperes, direct current with reverse polarity will deposit the second greatest amount of weld metal; and at the same amperage, alternating current will deposit the smallest amount of weld metal.

Other considerations may be more important, however, and these should be kept in mind. Use direct current with straight polarity for the utmost refinement in operating practice. If magnetic blow raises its ugly head, use alternating current and note with agreeable surprise, perhaps, that the better E6012 electrodes work quite well with alternating current. Or if, as may be the case in a shipyard, constant potential generators are set up for direct current with reverse polarity, use that combination.

Shallow Penetration a Characteristic

Shallow penetration characterizes this electrode group. The arc does not have the digging action associated with E6010 electrodes. Yet penetration is deep enough. It is the feature of shallow penetration that allows the E6012 group to be used for the welding of sheet metal where the $^3/_{32}$ and $^1/_8$-in. diameters are especially good. The best welding is accomplished at relatively high currents for such small diameter electrodes with the work so positioned as to permit the welder to travel downhill.

Slight variations in fit-up will give no trouble because of the outstanding bridging qualities of the weld metal. The "cold" deposit is not as susceptible to burning through as happens sometimes when E6010 electrodes are tried for this kind of fabrication. Better appearance may be achieved because the slag coverage of the E6012 electrodes is better than that of the E6011 and E6010 grades.

In some ways the E6012 electrodes are between the E6010 and the E6020 type. Particularly is this true of the slag factors. E6010 products have the least slag, next come the E6012 and, finally, the E6020 electrodes with the most slag. Matching these slag conditions are the ripples of flat beads produced with each variety. E6010 deposit ripple is the coarsest; E6012 ripples are much finer; and E6020 ripples are still finer. When the appearance of a welded unit must be just so for maximum sales appeal, fineness of ripples deserves attention.

Vertical welding characteristics of E6012 electrodes are different from those of E6010. Because of their shallow penetration, more abundant slag and less fluid weld metal, more skill is needed for vertical up welding with

E6012 rods. At best the layers will be more widely spaced with the weld showing appreciably more convexity when small fillets are being made. Wide welds, though, will present a most pleasing appearance when deposited with E6012 electrodes. Freedom from undercut makes vertical and overhead welding easier with this electrode classification than with either of the two groups discussed in the preceding articles.

Most of the special properties demonstrated by E6012 electrodes come from the titanium dioxide in the coating. Almost always this material is in the form of rutile although small amounts of the pigment grade of TiO_2 may be used as well. The rutile serves a dual function by providing much of the slag and by contributing largely to arc stabilization. Titanium dioxide is the largest single ingredient in E6012 electrode coatings.

Feldspar, aluminum silicates, magnesium silicates and calcium carbonate are added to the coating to secure the exact slag performance desired by the electrode designer. The calcium carbonate is believed to provide additional arc stabilization for straight polarity welding.

As is true of almost all electrode coatings, ferromanganese is included as a degasifier. Notwithstanding this addition, the deposit contains appreciable porosity. Quite likely this gas does not have a chance to escape from the molten pool because of the quick-solidifying nature of E6012 weld deposits.

Although the general-purpose electrodes are fundamentally of the mineral shielded types, some coatings are known to contain organic materials such as cellulose or lignin to provide an extra measure of gas shielding. As usual the coating materials are bound together with sodium silicate which also serves to bind the coating to the core wire.

Table 12 reports the deposit analyses of the weld metal

Table 12—Deposit Analyses Produced by E6012 Electrodes

		C	Mn	P	S	Si	Mo	Ni
Min.,	%	0.05	0.25	....	....	0.08	....	....
Max.,	%	0.15	0.55	0.03	0.035	0.12	0.025	0.025

from poor fit-up electrodes. This range in elements is smaller than those previously shown. Manganese is lower and silicon is lower, yet the strengths of weld metal are higher than they would be with E6010 and E6011 deposits. The closer limits are indicative of the similarity of coatings found throughout the many kinds of general-purpose electrodes all of which are predominantly of the titanium dioxide formulation.

Table 13 outlines the physical properties to be found when test plates are made in accordance with the method described in A.W.S.-A.S.T.M. A 233–43 T. Some specific observations are in order regarding the physical properties of E6012 electrodes.

Interpretation of "Cold" Varies

Just as cold weather means one thing to residents of Canada and quite a different thing to residents of Mexico, so does the term "cold electrode" mean different things to different electrode designers. A few of the E6012 electrodes on the market are very cold. The deposit is decidedly convex, porosity tends to be high even for this type of electrode and the elongation may even be below the minimum requirement of the specification on some occasions.

Other electrodes are more fluid, that is not nearly so

Table 13—Physical Properties of Deposits made with E6012 Electrodes

Property	Stress Relieved	Not Stress Relieved
Yield point, psi.	47–64,000	50–65,000
Ultimate strength, psi.	64–81,000	65–82,000
Elongation, % in 2 in.	22–28	17–25
Reduction in area, %	40–60	30–50
Izod impact resistance, ft.-lb.	.....	25–50
Fatigue resistance, psi.	.....	25–30,000
Specific gravity	7.80–7.85	

"cold" as the first group mentioned, yet possess a minimum of convexity, the least possible amount of porosity and ample elongation. The former may be faster allowing greater current to be applied to them while the latter, though slower, may permit the establishment of a neater appearing weld. Thus variations in the interpretation of the term "cold" may account for noticeably different values of physical properties. Not only the ductility is affected by the coating design but the tensile strength too, will swing through a range of almost 7000 psi. depending upon the coating used. Ranges in physical properties are affected by yet another factor—electrode diameter. Invariably tests made with $^1/_4$-in. electrodes show a lesser strength and a greater ductility than do identical tests made with $^3/_{16}$-in. electrodes.

In Table 14 are presented the recommended ranges for

Table 14—Current and Voltage Ranges for E6012 Electrode Applications

Size of Electrode, In.	Recommended Amperes	Recommended Volts
$^3/_{32}$	25– 90	16–20
$^1/_8$	55–140	20–25
$^5/_{32}$	90–200	21–28
$^3/_{16}$	110–275	22–32
$^7/_{32}$	140–325	23–35
$^1/_4$	175–500	24–40
$^5/_{16}$	240–625	26–42
$^3/_8$	300–750	28–45

current and voltage as applied to E6012 electrodes. Once again there is a tremendous spread from the low to the high value of current recommended for a particular electrode diameter. However the E6012 electrodes permit a great choice of current values. On thin metal the lower current is necessary while on thick steel the only limit to the current selected is the ability of the coating to stand up for 20 to 30 sec. at temperatures approaching 1500° F. It is the heat-proof (short time condition only) quality of certain E6012 coatings, demonstrated by sound welds produced under such normally adverse welding conditions, that make possible the phenomenal speed records established under production conditions with this electrode type.

Not only does the current show wide limits, but also the voltage recommended has quite a spread. Two factors are involved—chemical composition of the coating and thickness of coating. A chemical combination high in water content will give a big drop across the arc measured by increased voltage. Or a heavier coating will produce an identical result.

A rather short list of approvals is reported by electrode producers in connection with their literature on the E6012 electrodes. This group apparently satisfies the needs of the following bodies:

American Bureau of Shipping, Hull Class 1 and Boiler Class 1, All positions.

A.S.M.E. Code for Unfired Pressure Vessels, Paragraphs U69, U70.
Bureau of Marine Inspection and Navigation, Department of Commerce.
Lloyds Register of Shipping, Section 4, Paragraphs 1–9.

This bob-tailed list does not necessarily signify a lack of quality as some specifications may be more demanding than the service required. Still until welding is completely accepted as a sound method of fabrication, the natural conservatism of those engineers responsible for developing codes becomes understandable.

Where E6012 Electrodes Are Used

Where are E6012 electrodes used? Almost everywhere for odd jobs of fabrication and general maintenance and repair work. For building up worn metal without the establishment of a hard surface, E6012 electrodes are the proper choice. Walkways, small bridges, safety guards and a host of similar applications are ideally suited to the E6012 electrode.

Special truck bodies are built with E6012 electrodes where thin metals are easily joined with "cold" weld metal. Likewise tailor-made chassis and frames are constructed with this electrode group. Trailers, too, are fabricated of flame-cut parts welded together with general-purpose electrodes.

All sorts of containers for liquids ranging from milk cans to small liquid propane tanks are made with these poor fit-up electrodes. Usually light-gage metal sheets or very thin plates are involved. At the same time it is customary to build hundreds, or even thousands, of such containers all of which are exactly alike. Mass production techniques and E6012 electrodes make low costs a certainty.

More and more structural welding including massive bridges and huge buildings are intended for fabrication with E6012 electrodes. Most structural work involves thin sections. Here the general-purpose electrodes shine while welded design brings about simpler, cheaper and better functional structures. Bridge maintenance, also, becomes a practical outlet for the special characteristics of E6012 electrodes.

Light machinery parts are fastened with welded joints utilizing E6012 electrodes although the bulk of the machinery welding is done with other kinds of electrodes. Some mining machinery is built with general-purpose electrodes and oil well derricks, steps, platforms and so on are similarly welded. But the best pipe work is usually reserved for E6010 and E6011 electrodes with very little, such as casings or flumes, being accomplished with E6012 electrodes. Steel smoke-stacks, which in a way are similar to large diameter pipe, may be made with class E6012.

Steel reinforcing bars for reinforced concrete work are most often welded in place with E6012 electrodes. Duct work of black iron is welded with these electrodes, too. Some parts of engines and locomotives, particularly non-stressed parts, are welded with these poor fit-up electrodes. Many portions of freight cars are so built.

But the many examples of E6012 welding are numberless. A few typical applications have been mentioned to show specific uses in an effort to establish working ideas. A little experience with the E6012 electrodes group will prove a good teacher and the proper application of this group to the welding work where it performs best will come naturally.

The following Books and Pamphlets may be purchased through the AMERICAN WELDING SOCIETY, 33 West 39th St., New York 18, N. Y.

	Price per copy
Welding Handbook—Non-members	$6.00
Members	$5.00
Welding Metallurgy—A Fundamental course of Metallurgy & Metallography—1940	$1.50
Practical Design of Welded Steel Structures by H. M. Priest—1943 Edition	$1.00
Resistance Welding Manual	$2.50
How to Weld 29 Metals by C. H. Jennings—1937 Edition	85c
Research supplements of Welding Journal, issued each month in separate pamphlet form (Specify ones desired)	50c per issue
Welding Encyclopedia—Welding Engineer Publishing Co.—Eleventh Edition	$6.00 + postage
Procedure Handbook of Arc Welding Design & Practice—Lincoln Electric Co. (Seventh Edition)	$1.50 + postage
The Oxy-Acetylene Handbook—The Linde Air Products Co.	$1.50 + postage
Welded Steel Construction by Robert S. Hale	$3.00 + postage
Arc Welded Steel Frame Structures by Gilbert D. Fish 1933 Edition	$5.00 + postage
Bound Vols. Welding Journal, individual volume for members	$6.00 + postage
for non-members	$7.00 + postage
Arc Welding Handbook by C. J. Holslag—1941 Edition	$2.00 + postage
Welding and Its Application by B. E. Rossi—1941 Edition	$3.00 + postage
Electronic Control of Resistance Welding—G. M. Chute	$4.00 + postage
Lessons in Arc Welding—The Lincoln Electric Co.—1941 Edition	50c U.S.—75c elsewhere + postage
Practical Ship Production—by A. W. Carmichael	$3.00 + postage
The Instructor of Steel Arc Welding by W. R. Stunkard	$3.00 + postage
Training of Welding Operators—Air Reduction Sales Co.	
Oxyacetylene Welding (Lectures)	$1.00 + postage
Oxyacetylene Welding (Exercises)	$1.00 + postage
Arc Welding (Lectures)	$1.00 + postage
Arc Welding (Exercises)	$1.00 + postage
(Books may be purchased separately or the set of four)	$3.50 + postage
Aircraft welding—Exercises	$ .50 + postage

International Acetylene Association Publications

Oxy-Acetylene Cutting	25c
Oxy-Acetylene Welding & Its Applications	25c
Miscellaneous Uses of the Oxy-Acetylene & Air-Acetylene Flames	15c
Sample Pipe Welding Specifications	10c
Tests for the Selection of Welding Operators	20c
Bronze Welding or Brazing of Iron and Steel by the Oxy-Acetylene Process	20c
The Effect of Flame Cutting on Steel	25c
Hard-Facing by the Oxy-Acetylene Process	25c
Flame-Hardening by the Oxy-Acetylene Process	20c
Training Oxy-Acetylene Welding & Cutting Operators—Instructor's Outline	25c

Other Codes

A.S.A. Code for Pressure Piping 1942 Edition	$2.00

Sectional Ship Erection Welding Sequence

By Alfred E. Wallen*

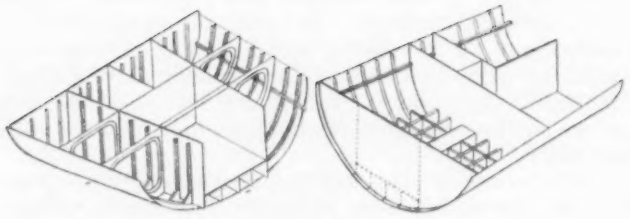


Fig. 1

THE sectional drawing in Fig. 1 is two sections of a sectionally constructed ship. The forward section shows in dotted lines, on the bulkhead and shell, the lines of abutment at which extruding floors and bulkheads of the aft section are to be welded in the joining of these two sections in erection welding.

It is the opinion of the writer that the greatest care should be taken to see that all major internal welding in each section be completed prior to their being welded together as a part of the ship. If the sections are completed after they are welded to each other, there can be serious disturbance and weakening of the strength lines which lie around the neutral axis. The amount of such disturbance, naturally, is dependent upon the amounts and types of welding done after the sections are welded together.

The drawing of the two sections in Fig. 2 shows them butted in erection. The abutments of the girders and longitudinal bulkheads on the transverse bulkhead and shell in the forward section are shown in dotted lines.

The expansion diagram of Fig. 3 shows the same erection girth butt, with welding operations indicated numerically in their performance order. Inasmuch as the above diagram shows only one side of the shell butt between the sections, it should be noted that the operations should be carried along simultaneously on both port and starboard sides, using a pair of welders.

* Welding Sequence Engineer, Walsh-Kaiser Co.

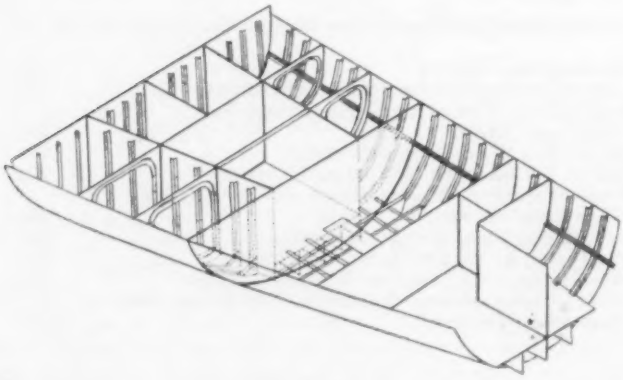


Fig. 2

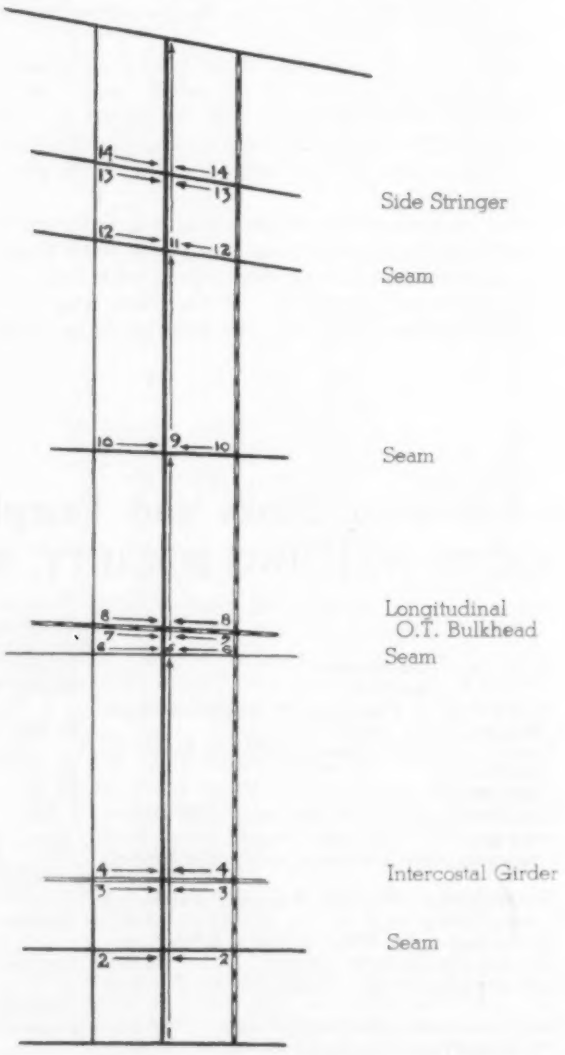


Fig. 3—Erection Vertical Shell Butt

The bevelled side, or outboard side, welding of the shell may be done prior to the closing beads, or inboard, welding, with the inboard welding to follow as closely behind as possible. Before starting on the inboard butt and inboard seam ends, the butt and seam ends should be chipped down into the root into clean weld metal as

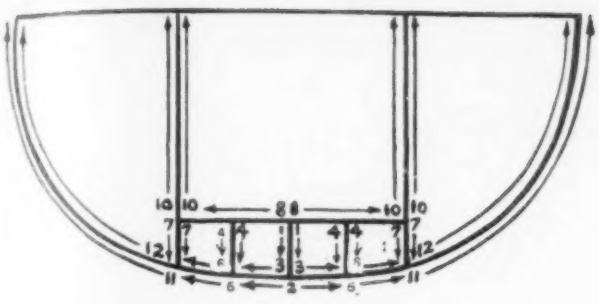
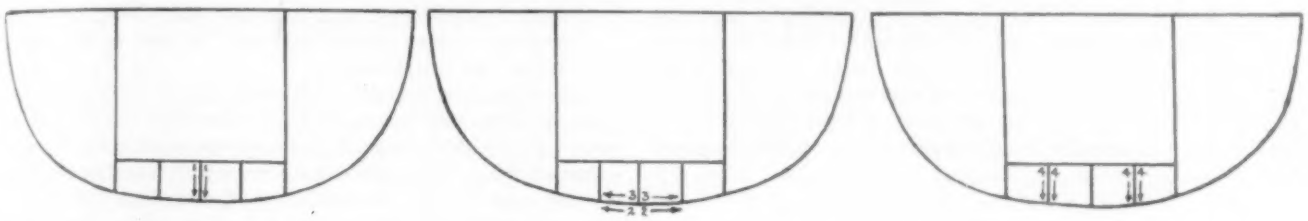


Fig. 4—Internal Abutments

be carried along with the welding of the shell butt. In the case of the vertical keel and longitudinal girders, the vertical welding should be done as it is arrived at. In the case of the longitudinal bulkhead, the vertical welding to the transverse bulkhead will be done when arrived at, but will be carried up only as far as the tank top. Then the welding of the tank top to the transverse bulkhead will be done, starting at the center, back-stepping, working outboard, simultaneously to port and starboard, using a pair of welders. When the tank top has been completely welded to the transverse bulkhead, the rest of the vertical welding of the longitudinal bulkhead will be done, working both port and starboard bulkheads simultaneously, using pairs of welders.

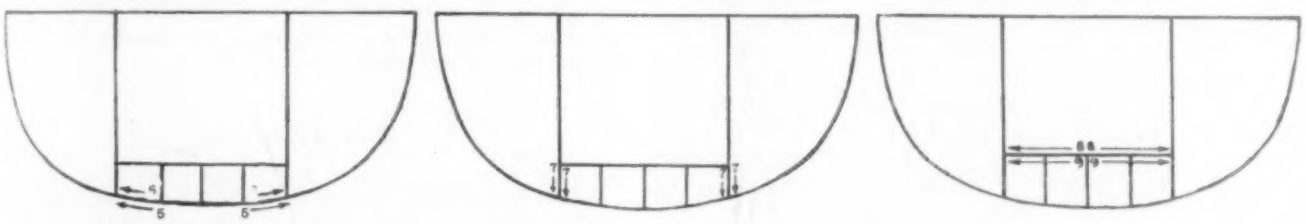
Fig. 5—Welding Internal Abutments By Operations



A pair of welders is to back step the weld from the tank top to the shell, one welder working slightly behind the other.

Use the back-stepping method—details on the shell expansion diagram.

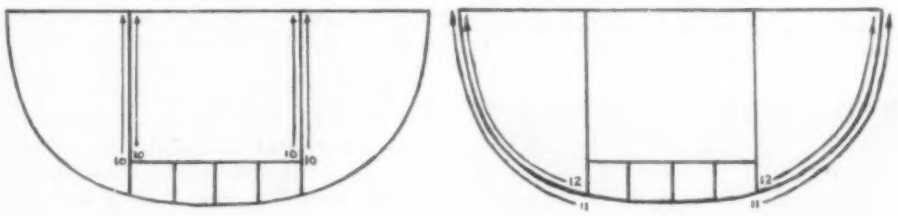
Vertical weld is to be applied as in operation No. 1, with operations to proceed simultaneously on port and starboard sides.



Same as operations Nos. 2 and 3, using the back-stepping method.

Same as operations Nos. 1 and 4, using the back-stepping method.

Using a pair of welders, back stepping from the center outboard, do the down-hand beads first (8), and then do the sealing beads (9) next, still back-stepping, as closely behind (8) as possible, always slightly behind.



Weld using the back-stepping method.

Use the back-stepping method, welding the bevelled side first, as detailed on the shell expansion.

deposited from the outboard side. Welding operations are to proceed on the inboard side in the numerical sequence as indicated on the diagram in Fig. 3, and *preferably before the weld metal deposited outboard has had a had a chance to cool completely.*

However, it should be noted that there are also some internal abutments which are not shown on the shell expansion diagram (see Fig. 4). The vertical and horizontal welding of these to the transverse bulkhead should

When this internal welding has been completed as stated, and as indicated in Fig. 5 in detail, then the welding of the shell may be resumed as indicated on the diagram, working both port and starboard sides simultaneously.

It is hoped by the writer that these observations may be of assistance to some welding supervisors who may have been, or are being troubled with the "welding sequence" problem in erection welding.

Hints on Silver Brazing

By H. H. Griffith*

SILVER BRAZING, sometimes called silver soldering or hard soldering, has been used for years in the manufacture of silverware and jewelry because it makes a strong joint and because the color of the base metal can be matched, but for industrial purposes it has many additional advantages, several of which are due to comparatively recent new developments and improvements in formulas by silver-brazing wire manufacturers. Many operations, difficult if not impossible to perform by welding, are readily and economically done by silver brazing. While the silver-brazing wire is relatively expensive per unit of weight, only a comparatively small quantity is needed for any one joint and consequently its cost does not materially affect the cost of the finished product.

Physical Properties

Silver, copper and zinc are the chief components of standard silver-brazing alloys—the silver content ranging from 10% to as much as 80%. The melting point varies with the composition, ranging from 1200 to 1500° F., which is, generally speaking, about midway between the melting point of ordinary solder and that of bronze welding rod. Tensile strengths run from 40,000 to 60,000 psi.; ductility from about 5 to over 35% in 2 in.; electrical conductivity from 14 to 77% of that of copper; and color from yellow to white. From this range of physical properties it can be seen that, within the indicated limits, a joint of almost any desired characteristics can be obtained if the correct grade of silver-brazing alloy is used. Specifications of eight standard grades are listed in Table 1. These specifications, prepared by the American Society for Testing Materials, have permitted industry to concentrate on eight standard grades of silver alloys that cover almost the complete range of the silver-brazing process. They have eliminated to a large extent the demand for a very great number of other grades that vary only slightly one from another or from these standard grades.

Grade 1.—Used where a temperature of 1600° F. will not damage the base metal.

Grades 2 and 3.—Used on copper, brass, bronze and other copper-base alloys; also on steel and on dissimilar metals.

Grades 4 and 5.—These are the popular grades for general, all-round use.

Grade 6.—Used by silversmiths because of the white color and low melting point; also excellent for Monel.

Grades 7 and 8.—Have extreme ductility; used for joining copper rods that are to be subsequently drawn into fine wire.

Silver brazing is best and most economically accomplished with the oxyacetylene blowpipe, although for some classes of light work, an acetylene-air torch may be satisfactory. The procedure for applying the alloy is simple. As in bronze-welding and ordinary soft-soldering operations, the parts to be joined must be thoroughly cleaned—first mechanically and then chemically. Apply a fine file, steel wool or emery cloth until bright metal is exposed. Then coat with flux. The edges and surfaces should be smooth and fitted tightly together. The merest film of silver-brazing alloy is sufficient to effect a good bond in a tight-fitting joint, and any greater thickness of the alloy is wasteful.

Flux Is Essential

Good fluxing is as important in silver brazing as it is in bronze welding. Flux dissolves any oxide that may form on the surface of the metal while heated, blankets the heated surface from atmospheric oxidation, and facilitates easy "tinning." There are several good prepared silver-brazing fluxes on the market. Apply the flux as directed by the manufacturer. Since the alloy will flow over the base metal wherever flux is present, materials and time will be saved if care is taken to put the flux only on those parts where the silver alloy is supposed to adhere.

Since most silver brazing is on relatively small work, the heat of an oxyacetylene lead-burning blowpipe or small sheet metal welding blowpipe is usually sufficient. For heavier work, however, particularly on metals that have a high heat conductivity, a large, full-size blowpipe may be required. After the parts have been evenly fluxed, heat the joint with a soft neutral flame, keeping

* The Linde Air Products Co., New York, N.Y.

Table 1—Standard Specifications for Silver Brazing Alloys

Grade No.	Silver, %	Copper, %	Zinc, %	Cadmium, %	Impurities, Max. %	Melting Point, ° F.	Flow Point, ° F.	Color
1	10	52	38	*	0.15	1510	1600	Yellow
2	20	45	35	*	0.15	1430	1500	Yellow
3	20	45	30	5	0.15	1430	1500	Yellow
4	45	30	25	0	0.15	1250	1370	Nearly white
5	50	34	16	0	0.15	1280	1425	Nearly white
6	65	20	15	0	0.15	1280	1325	White
7	70	20	10	0	0.15	1335	1390	White
8	80	16	4	0	0.15	1360	1460	White

* Addition of not more than 0.50% of cadmium to assist fabricating Grades 1 and 2 is not considered as a harmful impurity.

All Seams in This Battery of Copper Tanks Were Silver-Brazed

the blowpipe moving in circles, with the inner cone a couple of inches above the surface so that a spreading rather than a localized heat is applied. When the base metal has reached the melting point of the alloy, withdraw the flame and touch the end of the brazing wire to the surface. It will quickly melt and flow (due to capillary attraction) to all parts that have been cleaned and fluxed. The silver alloy flows so easily under the oxyacetylene flame that it penetrates quickly and deeply into all parts of the joint, leaving no pinholes.

Use Proper Heat

In order to obtain full advantage of the low temperature of silver brazing, it is, of course, most desirable not to heat the joint beyond the temperature required for free flowing and bonding of the brazing alloy. If the operator overheats the joint in order to be sure that he has a surplus of heat to melt the alloy, he will lose a great deal of the benefit of this low-temperature brazing process. On the other hand, if there is insufficient heat for the alloy to flow freely, it will tend to "ball up." If this happens, do not try to remedy the difficulty by applying more heat. It will only make matters worse. Instead, withdraw the flame until the joint has cooled sufficiently so that more flux can be applied and then it will be found that operation can be resumed in the normal manner. The knack of heating to the right temperature will be quickly developed with a little practice. The heat should always be applied only to the work—never to the wire or to the alloy in the joint itself.

Aside from the low temperature at which it can be applied, silver-brazing has several other distinct advantages. A silver-brazed joint has good resistance to shock and will stand up under conditions of constant vibration. For this reason it is extensively used in the assembly of loud-speakers and other delicate parts where excessive vibration is a factor to be reckoned with. Because of its high electrical conductivity and resistance to vibration, silver brazing has long been recognized as one of the most satisfactory methods of making electrical connections.

Corrosion Resistance

Silver brazing is also highly resistant to corrosion. Vats, tanks, kettles and similar equipment used in the chemical and food-processing industries are usually made of stainless steel or nickel alloys, such as Monel. These containers are often fabricated from thin sheet by flanging the edges and then fusion welding the flanged joint. This gives a strong joint with a stiffening rib on the outside of the container, but on the inside, where the two flanges meet, a crevice or a slight depression is left which affords a place where food particles might lodge. Filling with silver-brazing alloy is a quick and easy way of eliminating this crevice. This type seam is used not only for chemical equipment but also in the fabrication of refrigeration, automotive, textile, dyeing, laundry, dairy, cosmetic and brewery equipment. Through this combination seam, the advantages of the strength of fusion-welded construction are coupled with the corrosion-resisting qualities of silver alloy.

The battery of chemical tanks shown in the illustration were fabricated of copper and all seams, both longitudinal and circumferential, were silver brazed. Silver brazing is also extensively used in sweat-type fittings in copper and brass piping where the working temperature is too high for ordinary solder, or where ordinary solder would be subject to corrosion.

Many operators have never tried silver brazing because they have the mistaken idea that it is difficult to do. The fact is that any operator who has mastered fusion welding and bronze welding or who knows how to handle a blowpipe will have no difficulty whatever. Some oper-

To Apply Silver Solder, Hold the Inner Cone of the Flame a Couple of Inches Above the Surface and Use a Spreading Rather Than a Localized Heat

ators actually find it so simple that they are sometimes inclined to become a little careless. But with ordinary care it can be done entirely satisfactorily and at great speed. It should be remembered that silver brazing is not a substitute for welding—it is a valuable supplement to welding.

Three-Dimensional Lofting as an Aid in Jig Construction*

By John W. Clerke†

A SHORT time ago, the Airplane Parts Division of the Glidden Buick Corp. undertook to tool up for production one of the most complicated tubular steel frames used in aircraft construction in 60 days. This forward steel truss, as it is called, is utilized to take most of the concentrated loads in the fuselage of a well-known twin-engined wood construction bomber and gunnery trainer. This steel truss is embedded, as it were, in the forward section of this wooden fuselage, and is attached to it by means of the various circular formers that make up the framework for the fuselage skin.

This structure is not symmetrical. It is set in the wooden fuselage skewed over toward the left, so that the greater part of the truss is to the left of the center line of the airplane. This was done so as to provide for a sort of catwalk on the inside right side of the fuselage. This structure is composed of 200 separate tubular members, some square and some round, and upward of 150 separate fittings. Each and every one of these 200 tubes, and each and every one of these 150 fittings had to be located and welded in some sort of welding fixture. Every one of these tubes and fittings was a potential source of trouble because of shrinkage inherent in welded structures. It can readily be assumed that, in an unsymmetrical structure such as this, stresses and shrinkages caused by welding would be well-nigh unpredictable. This is because the structure is composed of square and round tubing, varying from $1^1/_2$ in. square to $^3/_8$ round, with nearly every size in between. Added to our problem, for good measure, was the requirement that many of the more important fittings were to be finish bored and reamed to ball-bearing fits and tolerances after welding, with little or no allowance made for misalignment prior to finish machining. In many instances, misalignment of $^1/_{32}$ in. after welding would mean breaking through the fitting wall in the final machining operation.

Let us take the three basic factors in order.

First, processing, or breaking down the job into economically fabricated subassemblies. Our breakdown was chiefly governed by production requirements. With a production schedule of two complete units per day, based on two 10-hr. shifts, we found that, without the necessity of duplicating tools, we could and did estimate the job so as to contain a time cycle for each subassembly welding fixture of not more than 10 hr. from start to finish. That is, each welding fixture must complete the operation assigned to it in 10 hr. or less.

The second basic factor in our program, tool designing, threatened to become the bottleneck. We all know that tools have to be designed before they can be built. Whether they are designed on paper or whether they are designed in the toolmaker's head, design time must be considered for any tooling program. We all agree, I trust, that proper and complete tool designing pays dividends in production. In other words, money spent on good tool design means money saved where it counts for most, on the production line.

The third basic factor in our program, tool fabricating, turned out to be the most inflexible element in our planning. We had at our disposal a definite number of man-hours available in our Jig Shop, together with a definite amount of floor space.

On estimating the total amount of shop time required for tool fabrication based on our 60-day program, we quickly realized that we would immediately have to begin tool-fabrication operations, and utilize every available man-hour in the Jig Shop, if we were to even hope to meet our delivery date.

We obtained the help of the Seaboard Engineering Company.

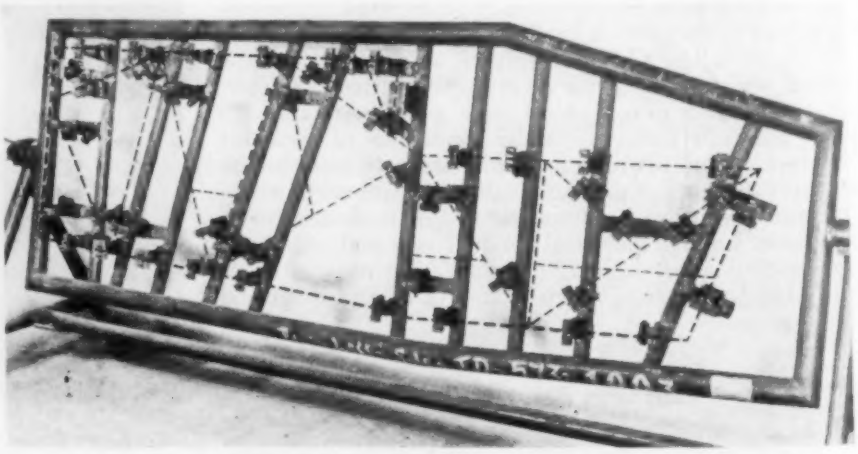
Seaboard engineers, working from the procedure and breakdown that we had mapped out, proceeded to make up preliminary sketches for basic structures for various welding fixtures. That is, knowing the general dimensions required for each subassembly, sketches showing the bare framework without any locating and clamping devices were furnished to the Jig Shop. The Jig Shop was thereby enabled to start tool fabrication immediately.

Our Jig Shop was primarily set up to utilize electric arc welding and considerable experience had been accumulated in the fabrication of welding fixtures built by the arc-welding process, utilizing, for the most part, iron pipe construction. Iron pipe has made it feasible to obtain a comparatively rigid basic structure, combined with simplified design and speedy fabrication. Electric arc welding has made the pipe frame practical.

Shrinkage is unavoidable in welded structures of this type. One of our problems had to do with designing our welding fixtures so as to provide adjustments for shrinkage allowance. This was a major problem because this steel truss is built up of 200 separate and distinct tubular members varying in size from $1^1/_2$ in. square down to $^3/_8$ in. diameter and in wall thickness from 0.065 to 0.035.

Two types of locators were developed that effectively licked this shrinkage problem. Both of these designs are simple yet ingenious.

Figure 1 shows a typical application of these standard locators to one of our tubular side frame subassembly fixtures. This fixture design shows typical electric arc-welded type of construction for the basic frame, also typical trunnion mounting which enables us to obtain 100% down-hand welding.



* Presented at December 13, 1943, Meeting, New York Section, A.W.S.

† Formerly with Airplane Parts Division, Glidden Buick Corp., now Cons. Eng., Beattie Mfg. Co., Little Falls, N. J.

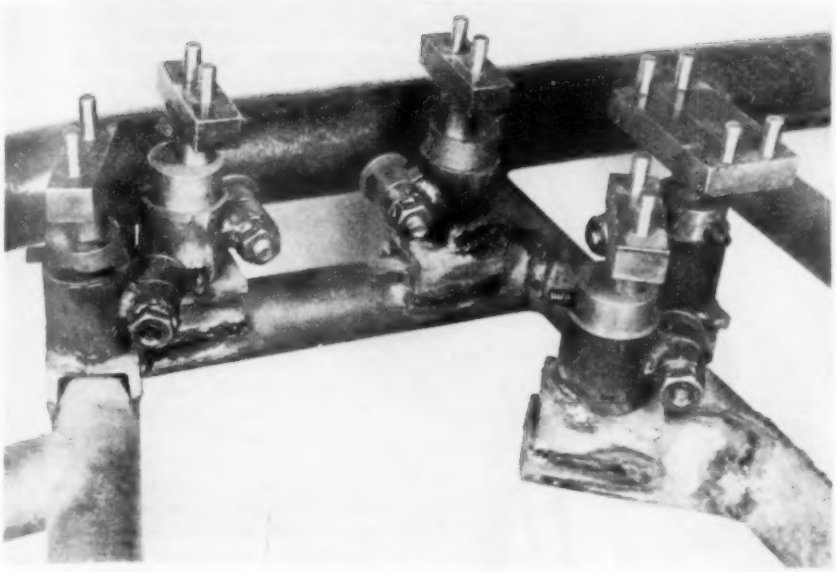


Fig. 2

On the cross bars of this fixture frame, we see mounted a number of our standard locators. These locators position the various tubular members of this subassembly. These tubular members are here shown by dotted lines; in other words, the dotted lines represent the actual work.

Figure 2 shows a close-up of some of these standard tube locators and also shows the means of adjustment. The tubes in each case are located by resting them on the cross member block between the two pins in each block. As can be readily seen, adjustment is simple yet positive. By loosening the clamp screw, the eccentric may be turned in either direction causing the locating block that carries the pins to rotate toward either side. It is necessary to loosen the set screws in order to bring the locating blocks at right angles to the work. By loosening the set screw, the rod to which the locating bar is welded may be caused to slide up or down in the eccentric, thereby providing for adjustment in a plane at right angles to the adjustment provided by the eccentric itself. Another feature of these standard locators is that they may be placed and welded to the pipe frame without regard to the close tolerances usually associated with this type of work. In fact, they may be located $\pm$ $^1/_8$ in. from the required position and corrected by means of the adjustment inherent in the locator.

Another type of locator shown in Fig. 3 was developed for use with some of our lighter subassemblies and also where space limitation did not permit the installation of our type No. 1 locator. A close-up of this No. 2 locator is shown in Fig. 4. It is simple in design and easily constructed requiring no machine work that cannot be done on the drill press. This clamp consists of a section of channel, welded to a $^1/_2$-in. bolt or headless set screw, and provided with a couple of set screws

Fig. 3

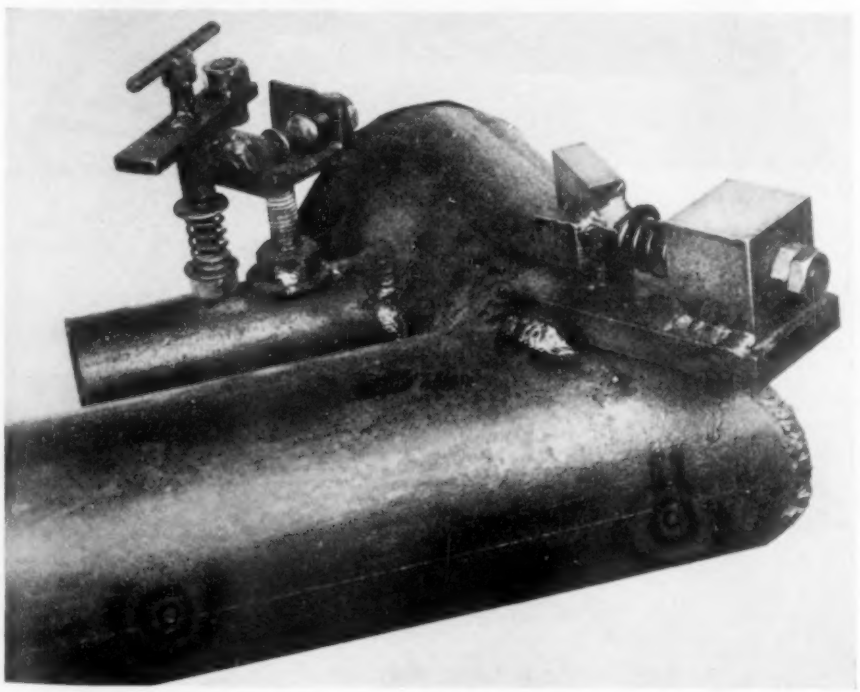


Fig. 4

threaded through the legs of the channel. This particular locator is shown with a simple but effective clamping device which, in turn, is welded to the channel. In order to position this locator, it is only necessary to drill a $^1/_2$-in. hole through the pipe frame, insert the threaded shank of the locator through the hole and adjust the height by means of the upper and lower check nuts. In order to allow for side adjustment, it is merely necessary to adjust the set screw in the channel section. This has proved to be a cheap and effective device. After final adjustment to compensate for welding shrinkage has been made, the adjustment is made foolproof by tack welding the adjustment screws to prevent deliberate or accidental movement.

This illustration shows another interesting feature. The block and spring arrangement welded to the corner of the pipe frame serves a two fold purpose. One purpose is to act as a stop and contour gage for the end of the tube to be located in the fixture (in this case the tube end is free). The other purpose is to allow for expansion of the tube while welding, without building up stresses that would result from restraining the ends of

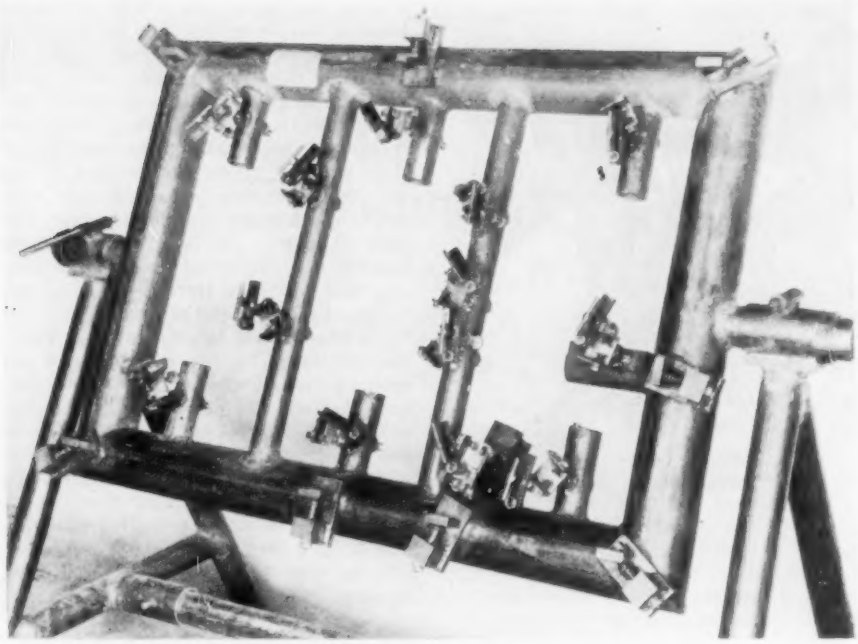


Fig. 5

the tube. In this case, the expanding tube bears against the spring-loaded gage which, in turn, is pushed back as the tube expands. This device also permits adjustment to compensate for longitudinal contraction of the tubes. Figure 5 shows a complete welding fixture utilizing this type of locator. The spring-loaded gages for the tube ends are also clearly shown in this view.

Figure 3 is, unfortunately, the only one that shows the work actually in the welding fixture. However, it shows to good advantage the application of our No. 2 locators equipped with spring clamps. This part happens to be a tubular framework support for the pilot's seat, and believe it or not, it comes out of the fixture after welding without using a hack saw on the fixture pipes. This fixture effectively illustrates the trunnion principle permitting 360° rotation and all downhand welding. It also illustrates the effectiveness of arc-welded pipe construction for unsymmetrical designs such as this. We can appreciate the advantages of being able to slap down a pipe wherever required and merely weld it in place, rather than struggle with the difficulties that would be involved with screwed and dowelled construction.

As we have just demonstrated, the first problem, compensating for material shrinkage caused by welding, has been effectively met by our two types of adjustable locators. The second problem was to cut down both design and fabrication time on our welding fixtures, through some simple yet positive means of positioning these standard locators.

We finally developed a method that simplified the designing and fabrication of these tools, a method that proved to be a lifesaver on our tooling program for the steel truss. In fact, this short cut has enabled us to meet our 60-day delivery date.

I have given this method the name "Three-Dimensional Lofting." Three-dimensional lofting is nothing more or less than transferring length and width dimensions to which orthographic projection is limited to length, width and *height* dimensions. This is done with a wood form built up to represent the location and proper angles of all of the tubes that make up one of the subassemblies of the steel truss.

In effect, the upper edges of the vertical members of this wood form represent the upper surfaces of the various square tubes that make up a subassembly of the steel truss structure.

This wood form is simple to lay out and build. The plan view of the upper edges of the vertical members is exactly the plan view as shown on the steel truss layout drawing. We simply duplicate the steel truss layout drawing, point to each tube intersection, and insert the height of the intersection from an established base line. This is all the information that the wood worker requires in order to make up this wood form. All he needs to do is to lay out his high and low points, draw a line between them, cut out his board and set it on the base according to his plan view.

These three-dimensional lofting forms have considerably reduced tool design layout time and manifestly cut down shop time. By the same token they have reduced the need for highly skilled jig and fixture builders.

Figure 6 (*A*) shows a form that was utilized to position about 50 of our standard locators for one of our subassemblies. Figure 6 (*B*) shows another form.

Figure 7 is something that looks like a tool designer's nightmare after he has had lobster, pickles, ice cream and beer. This seemingly fantastic arrangement was built in our Jig Shop by two semiskilled jig and fixture men. The really fantastic part about it, however, is that this welding fixture was built in the Jig Shop by these two semiskilled men without the use of a single solitary tool design drawing. Not even a sketch! All that these men had to go by was one of our three-dimensional lofting forms! They simply took this wood form, fastened it down to a couple of horses, proceeded to throw in two of our standard locators for each structural member to be located and built the entire fixture around the wood dummy. The welded subassembly comes out very easily, in spite of the manner in which these locators seem to interlock.

This is a fine example of electric arc welding and its time-saving possibilities. Two semiskilled jig and fixture men, with

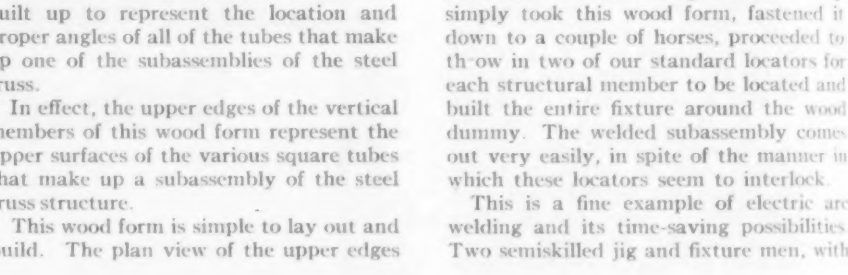


Fig. 6(*A*)

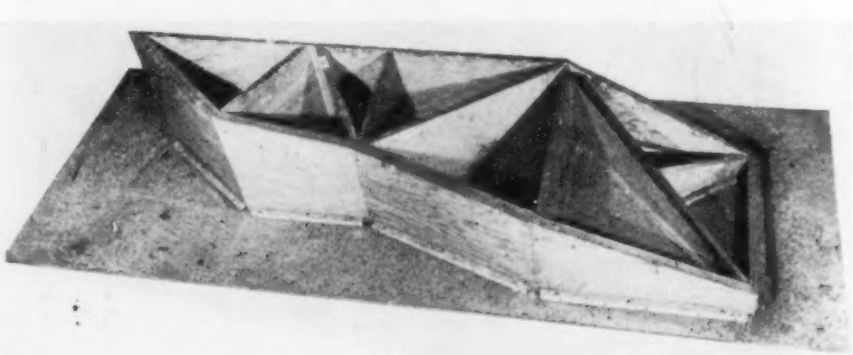


Fig. 6(*B*)

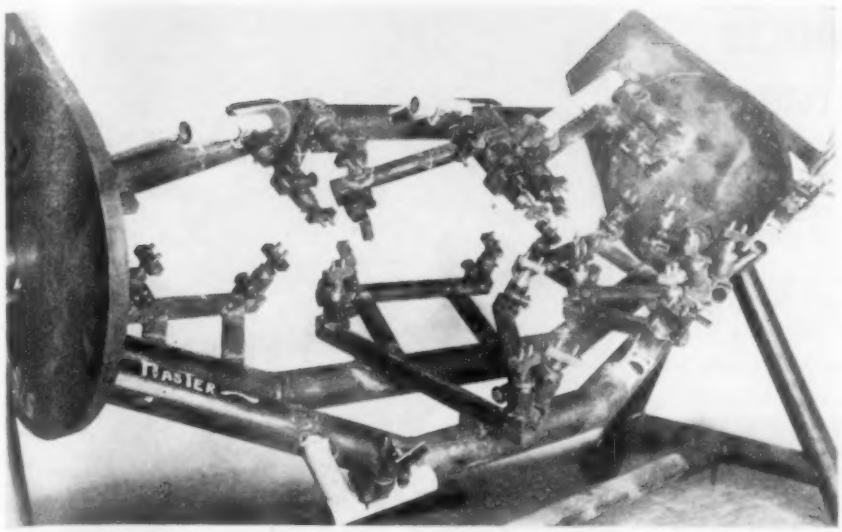


Fig. 7

the help of a welder, were able to build this fixture without any trouble. They did find a little unbalanced condition which made it difficult to rotate the fixture, but easily corrected it by welding those two extensions onto the original disk plates which form the two ends of the fixture. Of course, we try to trunnion most all of our welding fixtures, in order to obtain desirable down-hand welding.

So far we have been concerned with the welding of tubular subassemblies. Each of these tubular subassemblies, however, requires the welding on of various brackets, fittings, bushings and miscellaneous hardware.

For the location and welding of these fittings to the tubular subassemblies, we designed and built, separate fixtures for this purpose.

Figure 8 shows a typical example of a fitting assembly fixture. Here again we have an indication of what can be done with arc-welded pipe construction for fixture frames. This particular fixture with its double pipe frame is extremely rigid and stable. Our fitting assembly fixtures are also designed to provide for easy assembly and simple adjustment of the various brackets that we see attached to the frame. None of these brackets are directly welded to the frame but are screwed and dowelled on with provision for adjustment by means of shims underneath the base of each bracket.

I might mention that all of these welding fixtures were built without shrinkage allowances for the parts to be assembled. In this manner, we were able to check the part against the part drawing after it came out of the fixture, in order to determine the exact shrinkage. By using the first part as a trial, we would adjust our standard locators to compensate for shrinkage accordingly.

In conjunction with our program, I might add that we were able to control distortion to a great extent by taking advantage of progressive welding systems developed on other Glidden Buick products by Val Forgett of Air Reduction, and Frank Shaw of Glidden Buick.

A job that seemed impossible three months ago, has been accomplished by reducing the need for highly skilled help, both in tool design and tool fabrication, with results that have satisfied both the customer and ourselves.

I firmly believe that standardization of jig and fixture parts, wherever feasible, and the development of our three-dimensional lofting form, have made it possible to attain economical manufacture of this complicated steel truss.

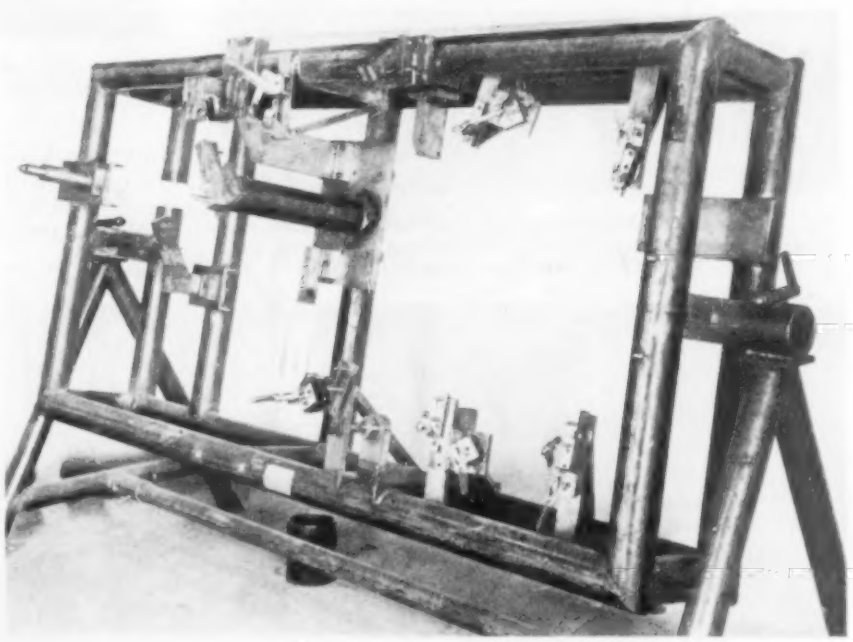


Fig. 8

Unique Jig Speeds Welding of Canteens

By W. F. Lautner*

OXYACETYLENE-welded aluminum canteens for the armed services are being turned out in large numbers on a novel production line at the U. S. Stamping Co.'s plant at Moundsville, W. Va. Ten identical jigs of a unique design devised by the company are worked by 15 girls, after it was determined that it would require the full time of one girl to apply flux to

* Applied Engineering Supervisor, Air Reduction Sales Co., Wheeling, W. Va.

Fig. 1—General View of Production Line for Aluminum Canteen Welding, Showing 5 Teams of Welding Operators, and Oxygen and Acetylene Pipe Lines on the Wall

Fig. 4—Operator Rotates Canteen by Turning the Handwheel Below While Making Edge Joint Without Filler Rod

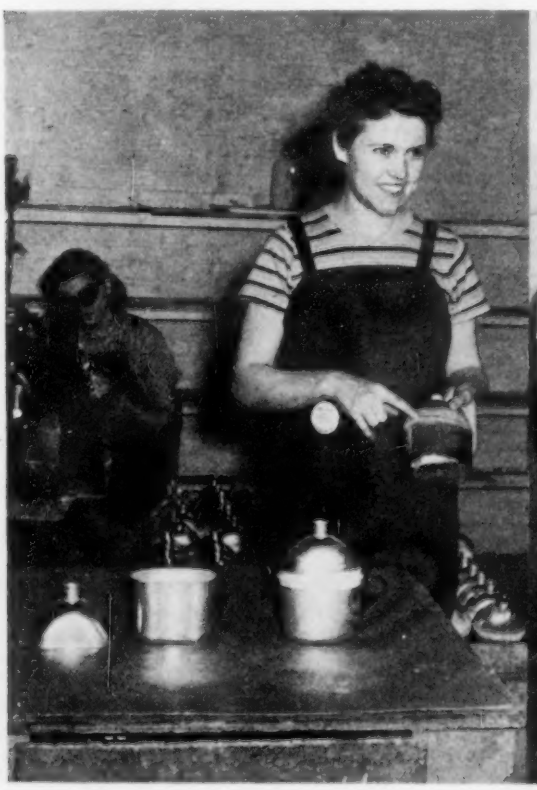


Fig. 2—Top and Bottom Sections of Canteens as Shown on Table Are Flanged for Edge Joint. Canteen at Right Is Fluxed for Welding, While the Girl Points to a Finished Weld

Fig. 3—Three-Girl Team Using Two Jigs. Girl on Right Applies Flux to Canteen Sections on Each Jig, Swings Them Around to Respective Welders

enough canteens to keep two girls busy doing the actual welding.

The production line begins with the punching of top and bottom sections for the canteens from sheet aluminum. These stampings are then cold drawn into proper shape and trimmed to exact dimensions, leaving a circumferential flange for the welding of an edge joint. The two halves are then forwarded to the welding department.

Three girls work as a team, using two of the welding jigs as shown in Fig. 3. This setup makes possible continuous operation of the torches, eliminating idle time or interruptions for jigging, fluxing or removal of finished canteens. There are five teams, and of the three girls in a team, one acts as fluxer, the other two as welders. Each welder has her own jig which swings between her and the fluxer. The jig consists of a flat skeleton panel pivoted on a supporting base and rotated horizontally by hand—like a turnstile with only two ends instead of four. It is fitted at each end with a fixture and chuck which holds the two halves of the canteen in alignment, positioned 60° from the horizontal for convenient welding unimpeded by work piece or fixture.

The fluxer in each group chucks the two halves of a canteen on one end of a jig, applies liquid flux to the seam with a brush, swings the work around to the welder at the other end, and replaces with new sections the finished canteen which swings around to her. The process is repeated on the other jig for the other welder, each jig being within easy reach of the girl applying the flux.

The fixtures which grip the halves of the canteen at the ends of the jig may themselves be rotated by means of handwheels which the operator turns with her left hand as she welds (Fig. 4). Each of the canteen sections is flanged along the seam for an edge joint, which makes possible a quick, easy weld without use of filler rod. The average weld is completed in 1 min. 12 sec., and there is almost no danger of burning through.

As may be seen in Fig. 1, special oxygen and acetylene pipe-line extensions were installed so that each welder has her own regulator station outlets. The gases are supplied by a stationary oxygen cylinder manifold and two 500-lb. double-rated acetylene generators, all housed in a small concrete building near the plant.

Approximately 0.09 cu. ft. each of oxygen and of acetylene are consumed in the welding of each canteen according to figures based on consumption of carbide and of cylinder oxygen in the production of 30,000 canteens.

WELDING
CODES, STANDARDS and SPECIFICATIONS

	Price per copy
Standard Qualification Procedure—1941 Edition	40c
Welding Symbols and Instructions for Their Use—1942 Edition	25c
Definitions of Welding Terms and Master Chart of Welding Processes—1942 Edition	40c
Standard Methods for Mechanical Testing of Welds—1942 Edition	40c
Code of Minimum Requirements for Instruction of Welding Operators (Part A—Arc Welding of Steel)—1942 Edition	50c
Tentative Specifications for Iron & Steel Arc Welding Electrodes—1943 Edition	25c
Tentative Specifications for Iron and Steel Gas Welding Rods—1942 Edition	25c
Tentative Specifications for Aluminum and Aluminum-Alloy Metal Arc-Welding Electrodes—1943 Edition	25c
Tentative Standards and Recommended Practices and Procedures for Spot Welding of Aluminum Alloys	$1.00
Recommended Practice for the Spot and Seam Welding of Low Carbon Steel—1943 Edition	10c
Code for Arc and Gas Welding in Building Construction—1941 Edition	50c
Specifications for Welded Highway and Railway Bridges—1941 Edition: Members / Non-members	75c / $1.00
Rules for Field Welding of Steel Storage Tanks—1940 Edition (with 1942 amendments)	25c
Rules for Fusion Welding Steam, Oil or Air Piping in Marine Construction—1938 Edition	25c
A. W. W. A.-A. W. S. Standard Specifications for Elevated Steel Water Tanks, Standpipes & Reservoirs—1943 Edition	30c

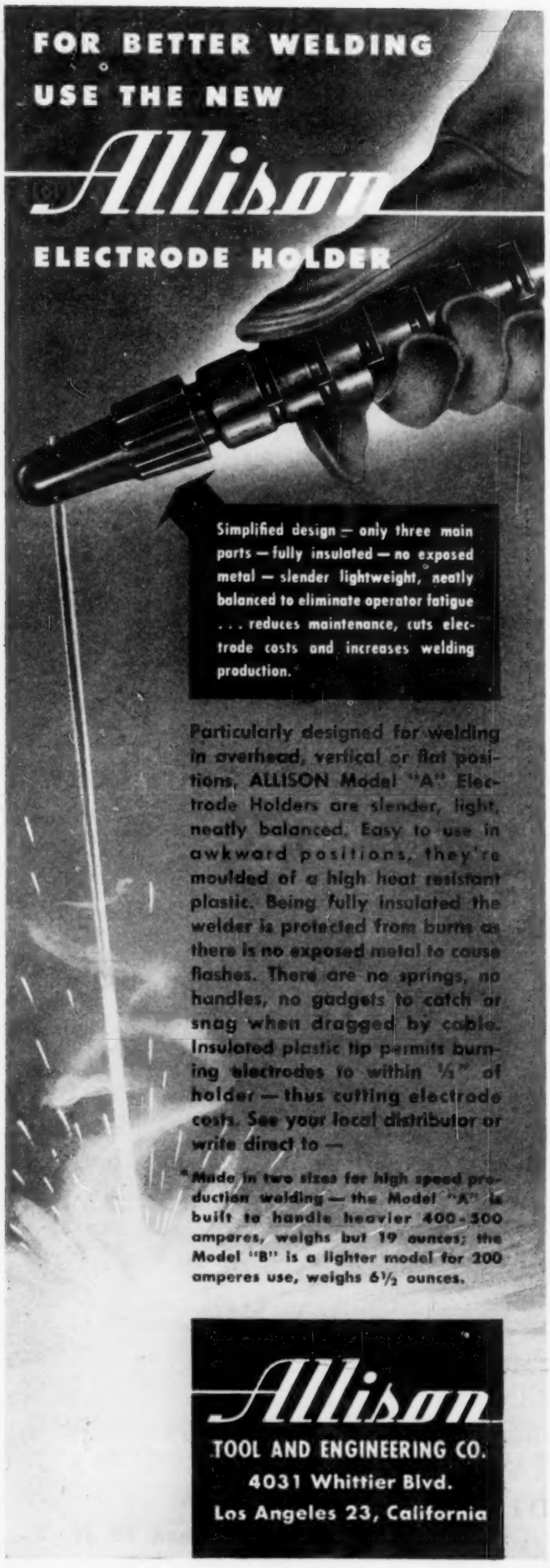
COMMITTEE REPORTS,
SPECIAL ARTICLES and BULLETINS

	Price per copy
Recommended Practices for Inspection of Fusion Welding—1942 Edition	40c
Report on Thermal Stresses and Shrinkage in Welded Ship Construction—1941	25c
Report of Committee on Welded Rail Joints—1932	$1.00
Reports of Structural Steel Committee: Welded Structural Joints—Test results and committee recommendations—1931	25c
Investigation of Welded Seat Angles—1934	25c
Welded Beam-Column Connection—1936	25c
Inspection Method Used in Manufacture of U-69 and U-70 Pressure Vessels—1939	10c
Filing Classification of Welding, Brazing, Soldering and Cutting Processes, Materials and Applications	50c
Engineering Essentials for Welders by H. M. Priest—(Reprint of 1942 article)	25c
Qualifying Welding Operators for Important Work—(Reprint of 1940 Article) Revised 1943	10c
The Measurement of Cooling Rates Associated with Arc Welding and Their Application to the Selection of Optimum Welding Conditions—1943 Edition	50c

Note: Round back blue Levant grain binder with 25 wires (gauge capacity 3") can be obtained for A.W.S. Codes, Standards & Specifications (Size 6" x 9"). Name and emblem of Society and Codes, Standards & Specifications stamped in gold on backbone. $2.25

AMERICAN WELDING SOCIETY

33 West 39th Street New York 18, N. Y.


FOR BETTER WELDING
USE THE NEW
Allison
ELECTRODE HOLDER
Simplified design — only three main parts — fully insulated — no exposed metal — slender lightweight, neatly balanced to eliminate operator fatigue . . . reduces maintenance, cuts electrode costs and increases welding production.
Particularly designed for welding in overhead, vertical or flat positions, ALLISON Model "A" Electrode Holders are slender, light, neatly balanced. Easy to use in awkward positions, they're moulded of a high heat resistant plastic. Being fully insulated the welder is protected from burns as there is no exposed metal to cause flashes. There are no springs, no handles, no gadgets to catch or snag when dragged by cable. Insulated plastic tip permits burning electrodes to within ½" of holder — thus cutting electrode costs. See your local distributor or write direct to —
*Made in two sizes for high speed production welding — the Model "A" is built to handle heavier 400-500 amperes, weighs but 19 ounces; the Model "B" is a lighter model for 200 amperes use, weighs 6½ ounces.
Allison
TOOL AND ENGINEERING CO.
4031 Whittier Blvd.
Los Angeles 23, California

Current Welding Literature

Airplanes, Fuel Tanks. "Short Circuit" Welding, G. E. Stedman. Steel, vol. 114, no. 19 (May 8, 1944), pp. 158–161.

Aluminum. Aluminum Welding with Liquefied Gas, J. V. Kielb. Iron Age, vol. 153, no. 18 (May 4, 1944), pp. 67, 152.

Brazing, Carbide Cutting Tools. Furnace Brazing, H. D. Samuel, Jr. Can. Metals & Met. Industries, vol. 7, no. 3 (Mar. 1944), p. 23.

Bridges, Steel. Economies in Welded Bridges, G. L. Enke. Western Construction News, vol. 19, no. 4 (Apr. 1944), pp. 74–78.

Electric Heating. Induction Hardening and Brazing, W. S. Craig. Can. Metals & Met. Industries, vol. 7, no. 2 (Feb. 1944), pp. 22–24.

Electric Heating, Induction. Stress Relieving—with Welding Machine, R. B. Foster. Steel, vol. 114, no. 19 (May 8, 1944), pp. 108, 110.

Electric Motors, Protection. Arcweld Ventilated Housings for Outdoor Motors, R. W. Gladson. Industry & Power, vol. 46, no. 3 (Mar. 1944), pp. 63–64, 138–140.

Electric Welding, Arc, Alloy Steel. Arc-Welding of High-Tensile Steels, H. F. Tremlett. Iron & Coal Trades Rev., vol. 148, no. 3970 (Mar. 31, 1944), 477–479.

Electric Welding, Arc. Atomic Hydrogen Welding, P. H. Take. Can. Metals & Met. Industries, vol. 7, no. 4 (Apr. 1944), pp. 33–34, 40–41.

Electric Welding, Arc. Automatic Arc Welding, G. W. Birdsall. Steel, vol. 114, no. 18 (May 1, 1944), pp. 100–103, 138, 140–141.

Electric Welding, Arc. Worn Parts Rebuilt by "Two-Tone" Arc Welding, J. A. Cunningham. Iron Age, vol. 153, no. 19 (May 11, 1944), pp. 72–73.

Electric Welding, Electrodes. Choose Proper Rod for Your Welding Job! E. H. Turnock. Steel Processing, vol. 30, no. 4 (Apr. 1944), p. 236.

Electric Welding Machines, Control. Instrument Signals Spot Weld Consistency, H. J. Hague. Iron Age, vol. 153, no. 19 (May 11, 1944), p. 77.

Electric Welding Machines. Maintenance of Resistance Welders, E. R. Spittler. Industry & Power, vol. 46, no. 5 (May 1944), p. 75.

Electric Welding, Resistance. Flash-Butt Welding, J. H. Cooper, J. J. Riley and J. C. Barrett. Iron Age, vol. 153, no. 15 (Apr. 13, 1944), pp. 60–65; no. 16 (Apr. 20), pp. 79–84; no. 17 (Apr. 27); pp. 48–54.

Electronics. Circuits of Electronic Controls, I, II, III, G. M. Chute. Elec. Contracting, vol. 43, no. 2 (Feb. 1944), pp. 90, 96, 100, 102; no. 3 (Mar.) pp. 102, 104, 106, 108; no. 4 (Apr.), pp. 108, 110, 112, 114, 116.

Electronics. Theory and Design of Electronic-Control Apparatus, W. D. Cockrell. Am. Soc. Mech. Engrs.—Trans., vol. 66, no. 4 (May 1944), pp. 249–258.

Gases, Safe Handling. Report of Committee on Gases. Nat. Fire Protection Assn.—Quarterly, vol. 37, no. 4, pt. 2 (Apr. 1944), pp. 72–103.

Heat Treatment, Electric. Induction Heating, H. B. Osborn, Jr. Iron & Coal Trades Rev., vol. 148, no. 3961 (Jan. 28, 1944), p. 128.

Iron and Steel Standards. Ferrous Metals. Am. Soc. Testing Matls.—Standards (1943 Supp.), pt. I, 1943, pp. 1–58, 117–208, 322–346.

Materials. Engineering Materials, 2 Vols. Vol. 1—Ferrous Metals, 369 pp., $7.50 (25*s* abroad). Vol. 2—Non-Ferrous and Organic Materials, 479 pp., $8.50 (30*s* abroad). A. W. Judge, 2 ed., Pitman Publishing Corp., New York 19; Sir Isaac Pitman & Sons, London, 1943. Illus., diagrs., charts, tables.

Volume 1 on ferrous metals, presents information on properties, composition, heat treatments, machining welding, etc; Volume 2, treats non-ferrous metals and alloys, plastics, rubber and ceramics.

Motor Bus Maintenance and Repair. Welding in Maintenance of Road Passenger Vehicles, N. H. Charles and G. Deacon. Sheet Metal Industries, vol. 19, no. 203, 204 (Mar. 1944) pp. 515–516, 518, (Apr.) pp. 701–702, 704.

Non-Ferrous Metals. Am. Soc. Testing Matls.—Standards (1943 Supp.), pt. I, 1943, pp. 59–103, 111–115, 146–155, 227–307.

Non-Ferrous Metals. Welding Non-Ferrous Metals, W. R. Coulter. Can. Metals & Met. Industries, vol. 7, no. 1 (Jan. 1944), pp. 16–20.

Oxy-Acetylene Handbook, Manual on Oxy-Acetylene Welding and Cutting Procedures. Published by The Linde Air Products Co., New York, 1943. 587 pp., illus., diagrs., charts, tables, $1.50.

Oxyacetylene Welding. Historical Development of Oxy-Acetylene Welding and Cutting, G. O. Carter. Sheet Metal Worker, vol. 35, no. 2 (Feb. 1944), pp. 26–28.

(*Continued on page 644*)

U. S. MARINES ON BOUGAINVILLE use palm trees for telephone poles as they string communication lines. Two stand guard with carbine and sub-machine gun.

Telephone Lines on Bougainville

THIS is a war of communications. The farther our forces advance, the more wires, telephones and switchboards they need. And war stopped the making of telephones for civilian use.

We regret that many here at home cannot now get telephone service and may not be able to get it for some time.

If you are one of those who are waiting, we'd like you to know that we will do everything in our power to minimize your delay.

BELL TELEPHONE SYSTEM

THE AMERICAN WELDING SOCIETY

ACTIVITIES – RELATED EVENTS

STRUCTURAL FAILURES IN WELDED SHIP CONSTRUCTION

The factors causing failure in welded ship construction and some suggested means for their control are presented in the report, "Structural Failures in Welded Ship Construction," published by the AMERICAN WELDING SOCIETY.

This report is an extension of the principles set forth in the previously published report, "Thermal Stresses and Shrinkage in Welded Ship Construction."

The new report is not presented as the last word on the subject, but rather to assist the shipbuilding industry in its welding problems until such time as the extended studies now being carried on are completed and reported.

Copies of the report are available in the form of a 6 x 9 in. bulletin from THE AMERICAN WELDING SOCIETY, at a price of 25¢ per copy.

"MACHINE FLAME CUTTING FOR ASSEMBLY LINE FABRICATION"

Air Reduction is distributing an illustrated 8-page booklet, "Machine Flame Cutting for Assembly Line Fabrication." The subject matter is based on a paper presented at the last annual meeting of the AMERICAN WELDING SOCIETY by C. O. Adams, Welding Engineer, Delco Products Division of General Motors.

The booklet describes assembly line fabrication of frames and other components for generators for Deisel electric units by oxyacetylene flame cutting, using machines of the multiple torch type. These machines were used for beveling, turning and shaping operations formerly performed by machine tools.

The accuracy and quality of the parts compare favorably with that of parts formerly produced by machining and the cost is considerably lower due to quick and flexible setup of the flame-cutting equipment.

Copies of the booklet (Form ADR-13) may be obtained from the main office of Air Reduction, 60 E. 42nd St., New York 17, N. Y., or from any of the company's branch offices located throughout the United States.

CRAFTSWELD CORPORATION HONORED

Craftsweld Equipment Corporation, Long Island City, N. Y., was honored by the addition of a Star to its Army-Navy "E" Pennant for outstanding production.

ACKNOWLEDGMENT

THE WELDING JOURNAL published an article by J. V. Kielb in the May issue, entitled "Organization and Reclamation of Tools and Gages." Our attention has been called to the fact that this article duplicates to a considerable extent material published by the same author in the December 23, 1943, issue of *Iron Age*, and suitable acknowledgment is made herewith.

FLAME THROWER DEMORALIZES ENEMY

Among our enemies, the Chemical Warfare Service has made a fearsome name for itself. At Munda and in the New Georgias, the Japs were dislodged from exceptionally strong positions by the use of flame throwers. Our men burned the brush in front of their installations and then moved in on machine-gun crews, forcing the Japs to move out in a hurry. Our flame throwers drove the Japs from their pillboxes in Tarawa. They are in use in Italy and exceptionally effective when brought into action under the cover of smoke. They are capable of shooting a sheet of flame a distance of about 80 ft.

This weapon is made up primarily of a fuel tank, compression tank and flame gun. It is a dual weapon, being usable either as a flame thrower or a signaling device. It is easily portable and readily adaptable to special situations. It was produced rapidly and to the high quality of strength and accuracy demanded by the CWS to a considerable extent through the use of a silver brazing alloy produced by Handy & Harman.

This alloy is used in six different spots in the assembled mechanism. It speeded up the assembly and assured the necessary leak-tight joints.

An outstanding advantage of the flame thrower is its use as a surprise weapon. It is brought into place quietly and the enemy has no inkling of its existence. A roar of flame—a flash—and the objective is taken.

X-RAY BULLETIN

The Picker X-Ray Corp., 300 Fourth Ave., New York, has just issued Bulletin No. 1444 illustrating their new 50 Kv. Industrial X-Ray Unit for low kilovoltage x-ray inspection. Special mention is made of the application of this unit to spot weld control.

WELDING'S PLACE IN CONSERVING METAL

Chuckful of valuable ideas on how welding can be made to cut replacement costs materially is an informative little bulletin titled "Conservation Welding" just issued by the American Manganese Steel Division of the American Brake Shoe Co., Chicago Heights, Ill.

Helpful suggestions cover a wide range of welding operations including the repair of tractor sprockets, manganese steel crusher mantles, clamshell bucket teeth, crusher liner segments, manganese steel rock hammers, crusher liner segments, conveyor screws, pusher shoes and many others.

The folder is well illustrated, and its preachment is that while in normal times it is occasionally cheaper to scrap a worn part, in these days of stringent metal shortages, the welding rod is a valuable friend in need. Ask for Bulletin 344-W.

SILVER-BRAZED HAND GRENADES

There is an old superstition, among primitive peoples, that men who bear charmed lives and cannot be killed by ordinary means can be downed by silver bullets.

When our enemy is entrenched and fortified in pillboxes, concrete emplacements and enclosed shelters for machine guns, it takes a silvered weapon to dislodge them. The weapon is a special hand grenade developed by the Chemical Warfare Service.

This hand grenade, the M15, was designed especially for assaults on pillboxes and foxholes. It produces a white phosphorus smoke and explodes, breaking into small particles that quickly start hard-to-put-out fires. It is very effective up to 100 yd. and everything within a 25-yd. range is likely to be a casualty. Thrown into a pillbox, it turns the interior into a fiery furnace. In its construction it has three joints brazed with a silver alloy, Easy-Flo, developed by Handy & Harman which has helped to speed its manufacture and assembly. It is being supplied to our troops in huge quantities.

PIPING CHART

Tube Turns, Inc., of Louisville, Ky., has recently published a handy, pocket-size dimensional data chart which gives complete quick-layout information on every Tube-Turn welding fitting and

RANSOME
WELDING POSITIONING EQUIPMENT
Now Available
THROUGH YOUR LOCAL
WELDING SUPPLY DISTRIBUTOR
To more effectively serve the welding industry, Ransome has established a new sales policy of direct distribution by local Welding Equipment Distributors throughout the United States.
For your future Positioning Equipment requirements, it will pay you to investigate the exceptionally complete Ransome line. Write us for complete information. We will supply it with the name of a nearby Ransome distributor.
Attention!
WELDING SUPPLY DISTRIBUTORS
Write us for full information on what this new sales policy can do for you!

INDUSTRIAL DIVISION **Ransome** MACHINERY COMPANY
DUNELLEN, NEW JERSEY
SUBSIDIARY OF WORTHINGTON PUMP AND MACHINERY CORPORATION

electronic Weltronic bulletins

WELDERS CONVERTED IN ONE MINUTE

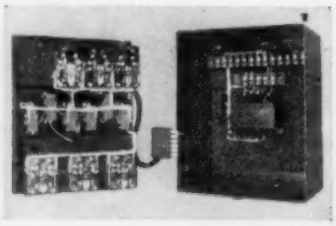
It takes less than one minute to change one Weltronic timer to another of either the same or a *different* NEMA type. Merely pull out a jackplug, lift off the control panel, insert another and plug *its* jack into the Universal power panel. No extra wiring.

Cuts timer investment. Saves shut-down time. In addition, Weltronic timers have EXCLUSIVE simplified circuits for reduced maintenance, fewer tubes, and a power unit that works on 115, 230 or 460 volts by merely shifting one jumper.

ALL THESE ARE "PLUS" VALUES AT NO EXTRA COST.

For detailed information on the complete line of Weltronic NEMA interchangeable sequence and weld timers,

Write for Bulletin #WTT-44



Weltronic COMPANY

DETROIT 19, MICH.

flange. Printed attractively in two colors, these 9 x 24-in. charts are ideal for spreading out on a drawing board or desk, or they can be folded up like a railroad timetable into a 9 x 4-in. folder and slipped into a pocket. Just make the request on a company letterhead and one of these charts will be sent free of charge.

HUGO W. HIEMKE WITH NATIONAL RESEARCH COUNCIL

Hugo W. Hiemke, until recently with the Bureau of Ships of the Navy Dept., is now supervising various welding research projects for the War Metallurgy Committee of the National Research Council.

Mr. Hiemke is a graduate of the University of Wisconsin, receiving a degree of Bachelor of Science in Chemical Engineering in 1926 and Master of Science in Metallurgy in 1933.

Hugo W. Hiemke

He has been associated with the welding and cutting field since 1927 when he was employed in oxyacetylene welding and cutting apparatus developments at Bastian-Blessing Co. of Chicago, Ill. In 1930 he joined the research staff of the A. O. Smith Corp. of Milwaukee, Wis., steel fabricators, as research engineer in their welding laboratory. Here he was engaged in arc welding process and electrode developments as well as resistance welding research.

Since 1934 he has been employed as welding and materials engineer for the Bureau of Ships (formerly Bureau of Engineering) acting as process development engineer for the welding, casting and radiographic processes, particularly as applied to the machinery of naval ships. He has been active in the development of Navy specifications for welding, including electrode specifications, process and operator qualifications and joint design standards.

In his new assignment, Mr. Hiemke will be concerned with a variety of research problems dealing with the welding of ordnance structures, aircraft and ships.

LOCOMOTIVE PARTS FABRICATION

How the American Railroads relieved a critical parts shortage by ingenious adaptations of various welding processes is described in a new 12-page booklet just released by Air Reduction.

The title of the new booklet is "Locomotive Parts Fabrication." The author is J. W. Kenefic, Superintendent of Railroad Service, Western Division of Air Reduction.

One of the most critical problems facing the railroads was the replacement of heavy parts made from scarce metals. Obviously welding was the most logical solution as it required only a few pounds of critical metal for restoring an old part as compared to the much greater weight used in a new component.

Mr. Kenefic tells of an interesting study of 350 locomotive parts, which disclosed that 90% of them could be effectively restored or fabricated by welding and flame cutting. Often the restored parts or shop-fabricated parts gave longer service than new ones.

Another interesting case is the 80% saving of strategic metal made in the restoration by welding of crown brasses for locomotive driving boxes. Other parts rebuilt by welding processes are stoker screws, water pump pistons, crosshead shoes, crate bars, brake heads and hangers.

The booklet describes in detail, and with numerous illustrations, how many of these operations were performed.

Copies of this booklet (Form ADR11) can be obtained by writing to the main office of Air Reduction Sales Co., 60 E. 42nd St., New York 17, N. Y., or from any Airco branch office.

WELDING COMPOUND

Users of PROTECT-O-METAL, made by G. W. Smith & Sons, 110 Sperling Ave., Dayton 3, Ohio, have found that it has virtues which the manufacturer did not anticipate.

Protect-O-Metal is a water-soluble compound which, when sprayed or brushed into the welding joint and upon the adjacent surfaces, is said to prevent the adherence of spatter, also to assist in producing a less porous and consequently stronger weld.

One of the interesting discoveries made by users is that the compound, because of its deoxidizing action, prevents the formation of scale in the annealing oven when welded structures are heat treated at up to 1500° F. to relieve stresses. Removal of the Protect-O-Metal coating after the heat treatment is said to be much easier and more economical than removing the scale which would otherwise form.

In the normal use of Protect-O-Metal for spatter-proofing, it is customary to wipe off the coating with a damp cloth in removing the spatter. Some users, however, leave the coating remain on the metal after brushing off the spatter, for

More and More
in Important Places

UNITED

MERCURY RECTIFIER
and
GRID CONTROL TUBES

for Resistance Welding

These features make UNITED Tubes better

1. Protruded filament, mounted on a vertical plane, increases emission area and affords greater capacity to withstand vibration and shock.
2. Greater shielding than is found in ordinary tubes permits proper thermal radiation for extended tube life.
3. Ideal relation between condensed mercury and ambient temperature is maintained.
4. Heavy duty quality is emphasized in all component parts and construction.

It is obvious, from the illustrations of these UNITED Tubes, that they are built to withstand the continuous hard uses of industrial applications in contrast to tubes designed to function under the less stringent conditions of radio communication.

TYPES ILLUSTRATED: The UNITED types illustrated will interchange with and replace other type tubes as follows:

USE UNITED TYPE	967	to replace	FG-17
" " "	972-A	" "	872-A
" " "	UX-973	" "	——
" " "	973 (Not illustrated)		873

UNITED ELECTRONICS COMPANY

Newark 2 New Jersey

they have found that the compound provides an excellent base for paint or lacquer. If welded fabrications are not to be painted or lacquered, or if they are to be unfinished for some time, it has been found that a complete coat prevents rusting.

THE EXTRUSION OF METALS

For metallurgists and engineers—a concise account of extrusion practice as it relates to different classes of work and materials, including . . . flow phenomena in the process . . . the influence of temperature, speed and extent of deformation on the extrusion of metals . . . impact extrusion . . . specialized methods. Reference to welding included. By Claude E. Pearson. Published by John Wiley & Sons, Inc., 440 4th Ave., New York 16, N. Y. 305 pp. Price $3.75.

Clinton E. Swift

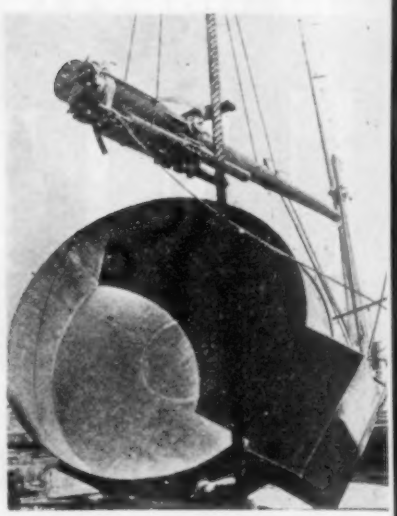
JOINS EUTECTIC ENGINEERING STAFF

Clinton E. Swift, M.E., University of Illinois, has been made assistant manager of the Engineering and Research Department of Eutectic Welding Alloys Co. Before joining Eutectic, Mr. Swift was the manager of the welding division of Ampco Metal, Inc.; prior to that he was a welding engineer for the C. F. Braun Co. of California. He also was on the engineering staffs of American Brass Co. and Westinghouse Electric and Manufacturing Co., East Pittsburgh.

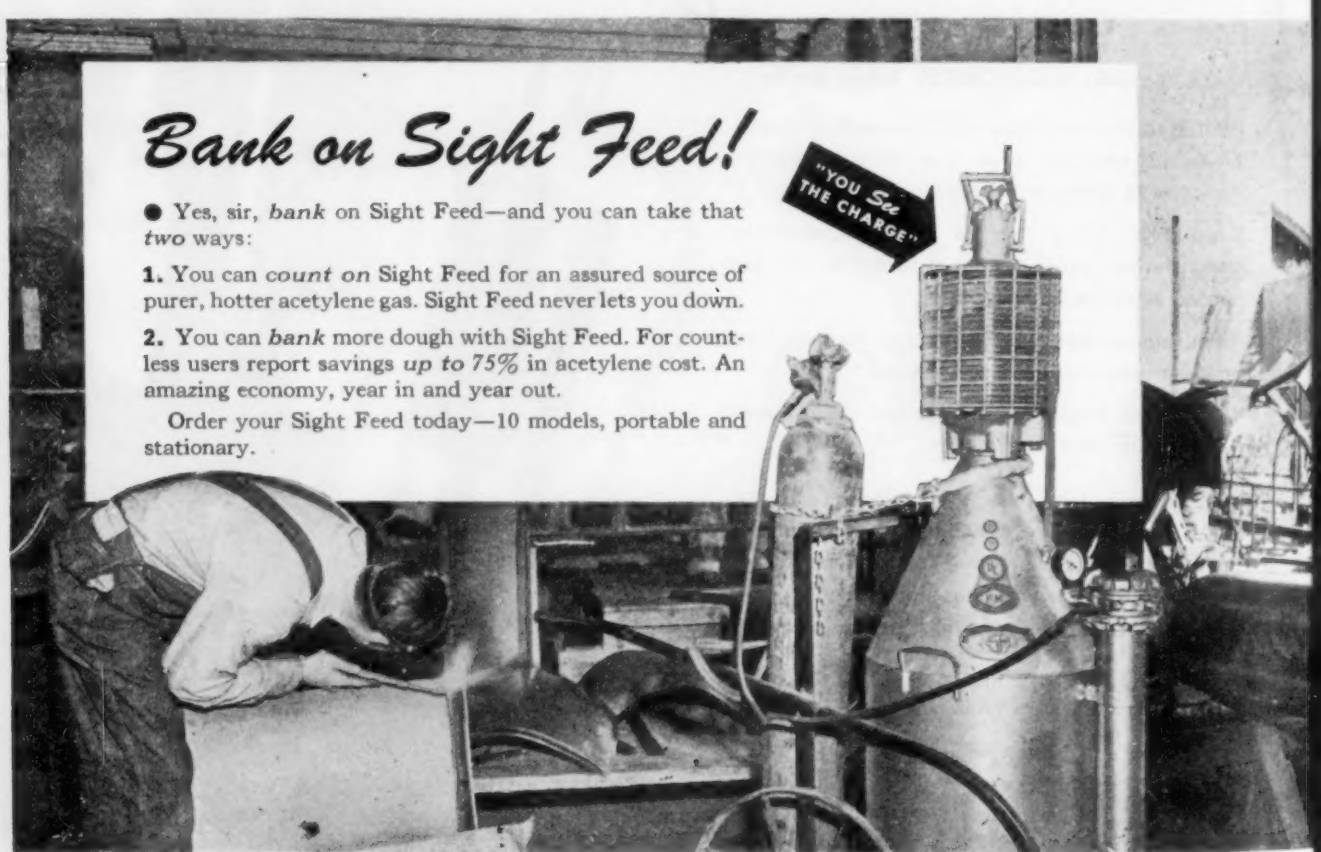
The Eutectic Engineering and Research Department is headed by R. D. Wasserman, inventor of the "Low Temperature" process and alloys. "Clint" Swift will handle industrial welding problems where his experience renders him particularly valuable. Along with his other duties, Mr. Swift will also act as one of the three technical advisers for "The Eutectic Welder," the other two being Mr. Wasserman and Harry Kough, welding specialist.

WELDED PLATFORM FOR U-BOAT LIQUIDATOR

This all-welded gun platform with anti-sub gun shown suspended above is a typical example of the many essential steel-fabricated items made possible by arc welding to speed a total victory.



Official U. S. Navy Photograph, courtesy The Lincoln Electric Co.


Bank on Sight Feed!
● Yes, sir, *bank* on Sight Feed—and you can take that *two* ways:
1. You can *count on* Sight Feed for an assured source of purer, hotter acetylene gas. Sight Feed never lets you down.
2. You can *bank* more dough with Sight Feed. For countless users report savings *up to 75%* in acetylene cost. An amazing economy, year in and year out.
Order your Sight Feed today—10 models, portable and stationary.
"YOU Set THE CHARGE"
THE Sight Feed GENERATOR COMPANY • SALES: RICHMOND, IND. • FACTORY: W. ALEXANDRIA, O

ARC-O-MAT SAVES 31.7% SHIPYARD POWER LOSS

Careful tests by welding engineers in one of the country's largest shipyards showed that 75% of the power-time of its thousands of welding machines was NOT arc-time but "idling-time." And the net total power waste was revealed as 31.7% of the total welding power consumed. Besides, these tests were based upon only the 21 hours out of a full 24-hour day that the welding machines were actually turned on. These same shipyard engineers found how to end this 31.7% loss of welding power. In their published report, they tell how automatic starters on the welding machines made this decisive saving—enough to pay for the starters in 6 to 7 months. After that, the starters kept on making the same monthly savings.

The starters that made these waste-stopping savings were *-hp-* Arc-O-Mat. In whatever industry this power waste of "idling" welding machines exists, it is usually far greater than is supposed. As is the case of the shipyard, a careful check in your plant would very likely reveal power waste of a magnitude far greater than ever suspected.

If you, too, would like to stop this loss of power, ask for a reprint of this shipyard "Waste-Power Report." Naturally there is no obligation; a copy will be forwarded you by return mail.

The -hp- model 1010 Automatic Welding Machine Starter with Arc-time Totalizer is designed to operate in conjunction with any standard welding motor-generator set. It starts the welding machine when the welder touches the rod to the work. After a short interval of no welding, the control automatically stops the machine. Whenever welding is in progress, arc-time is counted by a synchronous totalizer. The totalizer does not operate when the rod is shorted to the work, thus only actual arc-time is recorded.

ARC-O-MAT

HEWLETT-PACKARD COMPANY • PALO ALTO, CALIFORNIA

Box 808 F, Station A

Photographs courtesy Lincoln Electric Co.

Current Welding Literature

(*Continued from page 632*)

Oxyacetylene Welding, Zinc Alloys. Joining Zinc Alloys, A. G. Dornach. Metal Industry (Lond.), vol. 44, no. 9 (Mar. 3, 1944), p. 135.

Penstocks at Green Mountain, P. J. Bier. Western Construction News, vol. 19, no. 4 (Apr. 1944), pp. 64–68.

Pipe Lines, Maintenance and Repair. Repair of Gas Line Under Pressure, J. Novak. Petroleum Engr., vol. 15, no. 7 (Apr. 1944), p. 172.

Pressure Vessels. Riveted and Welded Pressure Vessels—V, H. C. Hesse. Southern Power & Industry, vol. 62, no. 4 (Apr. 1944), pp. 114, 116, 118.

Pressure Vessels. Test Pressure and Safe Dimensions of Welded Pressure Vessels, H. F. Lassner. Petroleum Refiner, vol. 23, no. 4 (Apr. 1944), pp. 135–138.

Rails, Welding. Six Miles of Rails and No Joint Anywhere, M. L. Smith. Compressed Air Mag., vol. 49, no. 1 (Jan. 1944), pp. 8–9.

Shipbuilding, Prefabricated Parts. Development of Fabricated Sternframes for Merchant Shipbuilding. Shipbldr. & Mar. Engine-Bldr., vol. 51, no. 418 (Mar. 1944), pp. 85–88, 1 supp. sheet; see also Shipbldg. & Shipg. Rec., vol. 63, no. 9 (Mar. 2, 1944, pp. 200–201.

Shipbuilding, Prefabricated Parts. Fabricated Shaft Bracket Shipbldr. & Mar. Engine-Bldr., vol. 51, no. 418 (Mar. 1944), pp. 94–95.

Shipbuilding. Recent Welding Developments in British Merchant Shipbuilding, R. B. Shepheard. North-East Coast Instn. Engrs. & Shipbldrs.—Trans., vol. 60, no. 6 (Apr. 1944), pp. 155–76.

Shipbuilding. Time Study of Manual Electric Welding in Shipbuilding, H. H. Hagan. Shipbldg. & Shipg. Rec., vol. 63, n. 13 (Mar. 30, 1944), pp. 304–306.

Shipbuilding. Welding Developments in British Merchant Shipbuilding, R. B. Shepheard. Engineering, vol. 157, no. 4078 (Mar. 10, 1944), pp. 198–200; no. 4079 (Mar. 17) pp. 218–220.

Shipyards, Accident Prevention. Fume Control in Shipyards, W. E. Lawrence. Nat. Safety News, vol. 49, no. 4 (Apr. 1944) pp. 16–17, 90, 92.

Soldering. Electro-Tinned Sheet, A. W. Hothersall, D. W. Hopkins and G. L. Evans. Iron & Coal Trades Rev., vol. 148, no. 3972 (Apr. 14, 1944), p. 556.

Steel Metallurgy. Effect of Wartime Developments on Future Steels, W. P. Eddy, Jr. Soc. Automotive Engrs.—J., vol. 52, no. 5 (May 1944), (Trans.), pp. 169–180 (discussion), 180–182.

Welders, Training. Qualification of Arc Welding Operators, A. Madson. Machine Tool Blue Book, vol. 40, no. 4 (Apr. 1944), pp. 199–200, 202, 204.

Welded and Riveted Joints, J. Dearden. Iron & Coal Trades Rev., vol. 148, no. 3962 (Feb. 4, 1944), pp. 171–173.

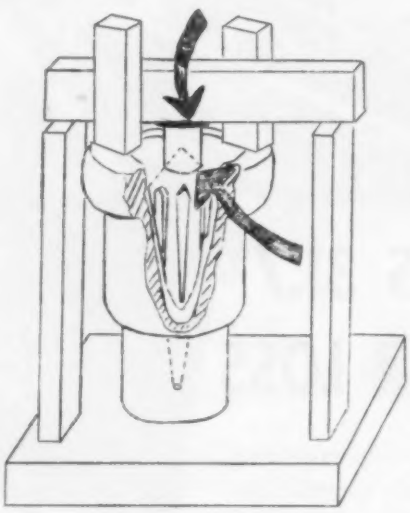
UNUSUAL REPAIR JOB ON EXTRUSION PRESS

By George H. Smith*

IN the manufacture of insulators, many extruded plastic or porcelain shapes are used. On the extrusion press which makes these insulators, it is not uncommon for a torpedo to freeze in the cylinder, as shown in the accompanying sketch. As the area of the point is very small, any effort to drive the torpedo out from the small end of the cylinder results in breaking this small point, rendering the torpedo useless. Heating the cylinder and burning out the mix that is being extruded is a long and costly operation.

Since only a very small area was accessible for welding, a welding rod had to be selected which combined maximum strength with the lowest possible temperature of application. High-tensile arc-welding rods were unsuitable because it was impossible to make a strong weld to the hardened torpedo. Bronze welding was tried, but the joint would not stand the load to be applied.

We solved the problem by low-temperature brazing, with a high-strength, free-flowing copper rod (for joining steel at 1300° F.), a steel stem to the large end of the torpedo, this stem, in turn, being welded to a crossbar, as shown in the illustration. By hanging this crossbar on two uprights and pushing on the cylinder with the spacers shown, it was simple to pull the torpedo out of the cylinder in which it



was frozen. The welding procedure was simple. The mix was cleaned away from the large end of the torpedo and the stem was set in place and suitably fluxed and then oxyacetylene welded with the copper rod (for joining steel at 1300° F.). A pressure of 4000 lb. was required to move the torpedo, and the weld held without failure.

* Welding operator.

THIRD "E" AWARD TO SUMMERILL

Employees of Summerill Tubing Company received word from Robert P. Patterson, Under Secretary of War, that their continued high production had won a third Army-Navy "E" Award.

Original Award was made in November 1942, and notice of the second award, with first star, was received last summer, and now the third Award is gratifying indication of the continued enthusiasm and interest on the part of all Summerill employees.

An affiliate—Columbia Steel and Shafting Company, Carnegie, Pa., received word of its third Award with second star, so both producing units in the Columbia-Ward-Summerill affiliation rate high in war production.

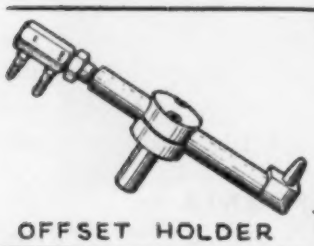
Annual Meeting

Plan to attend

Oct. 16–19

HOTEL CLEVELAND

Cleveland, Ohio



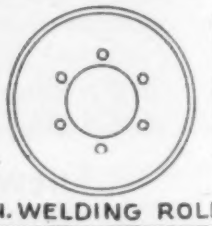
OFFSET HOLDER

"ELECTROLOY" for RESISTANCE WELDING

Butt
Flash
Spot
Seam
Projection

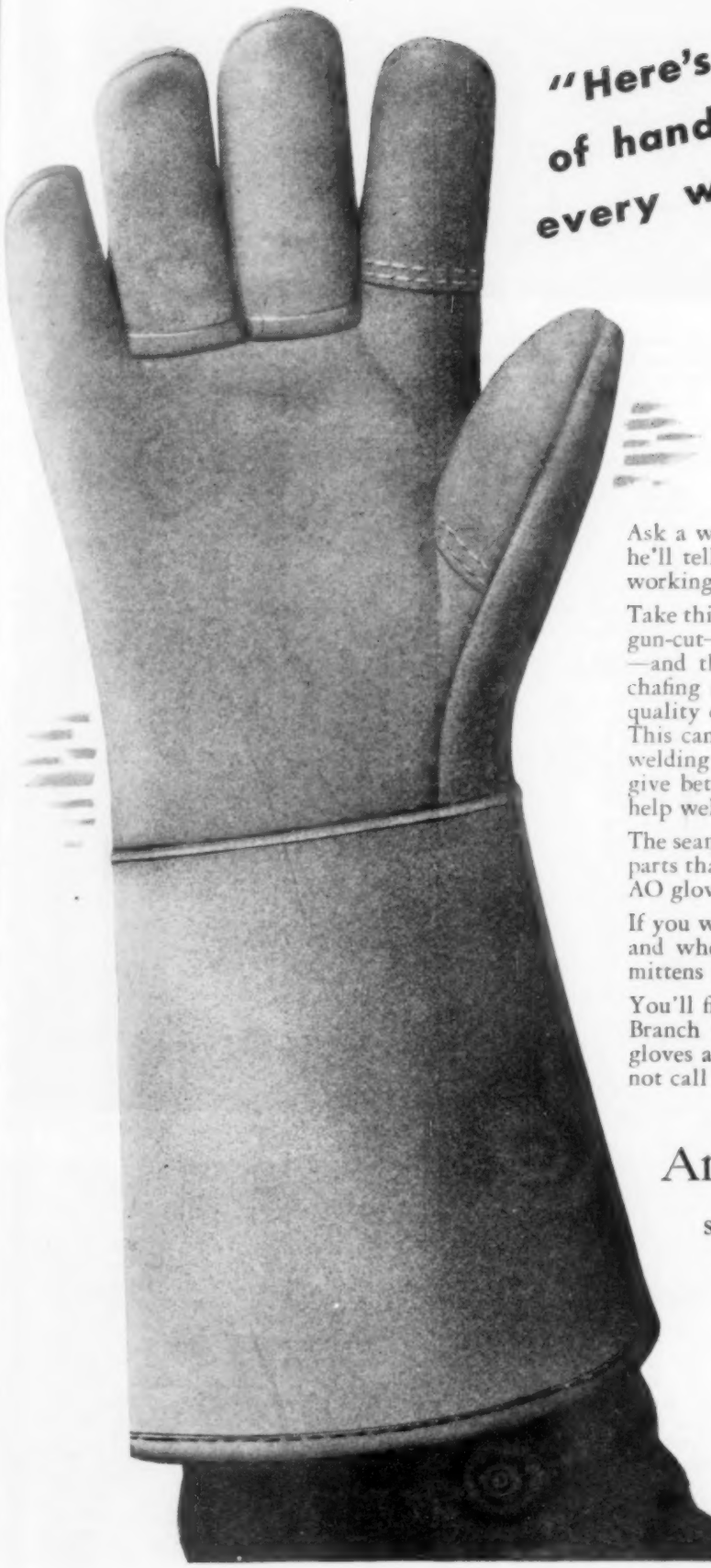
ELECTROLOY

Catalog and prices on request



WELDING ROLL

THE ELECTROLOY CO. INC. 1600 SEAVIEW AVE. BRIDGEPORT, CONN.



"Here's the kind of hand protection every welder wants"

Ask a welder what he wants in a glove . . . and he'll tell you he wants protection with plenty of working comfort.

Take this pair of American Optical gloves. They're gun-cut—which means they have seamless palms—and the finger seams are flat to guard against chafing and blistering. And they're made of top quality chrome tanned cowhide that *stays* pliable. This can make the difference between an ordinary welding job and a good job. For *pliable* gloves give better control of both rod and torch. They help welders do faster, more uniform work.

The seams on AO gloves are located away from the parts that get the most heat and wear. That's why AO gloves can take plenty of punishment, too.

If you want to step up your welding production—and who doesn't these days—give AO gloves or mittens to *your* welders.

You'll find the Representative of your nearest AO Branch Office can help you choose the proper gloves and mittens from AO's welding line. Why not call him sometime today?

American Optical
COMPANY
SOUTHBRIDGE, MASSACHUSETTS

MOBILE ELECTRIC POWER STATIONS

Even electric power stations have been made mobile in this war of movement. Engineers have put power "on the rails" by designing the Power Train, an electric generating station on railroad cars.

To restore electric service in cities reconquered by United Nations' armies, the Westinghouse Electric and Manufacturing Co. is building nearly a dozen of these Power Trains, each capable of generating 5000 kw., and will soon begin building more than 20 trains of 1000 kw. capacity.

In the larger Power Trains, all the pipes, turbines, generators, pumps, boilers and even living quarters for the crew have been skillfully fitted on eight railroad cars. The smaller Power Trains will consist of three cars.

The eight-car train contains two boiler cars each designed to produce 40,000 lb. of steam an hour even with the poor grade of coal found in certain parts of Europe. This steam is piped to a turbo-generator car with the exhaust steam going to two condenser cars. Here electrically driven fans draw hundreds of thousands of cubic feet of air through the condensers every minute to convert the exhaust steam into water so it can be fed into the boilers again.

The Power Train is designed to operate in extreme heat or cold—from 40 below zero to 95 above.

An Oxyacetylene Torch Throws Up a Barrage of Sparks as a Welder Works on a Big Steam Line for a Westinghouse Roving Power Train Which Will Restore Electric Service in Cities Reconquered from the Axis by United Nations' Armies

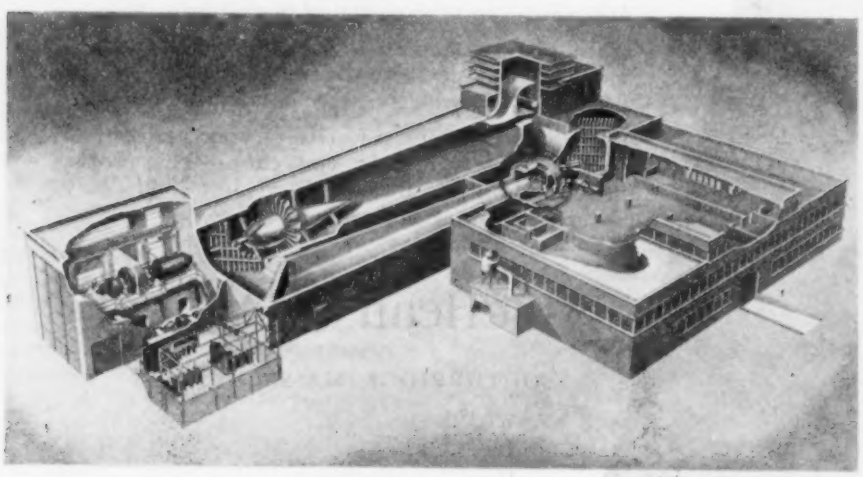
WIND TUNNEL

America's fastest large wind tunnel, an aeronautical "test tube" capable of generating super-hurricanes approaching the speed of sound in which will be born and nurtured many of the planes of the future, was dedicated by the Boeing Aircraft Co. in impressive ceremonies.

Named the Edmund T. Allen Memorial Aeronautical Laboratories in honor of the famed Boeing test pilot and scientist who lost his life last year in an airplane test accident, the new wind tunnel is a modern research unit with many features which mark it as a distinct step in the progress of the aviation industry.

Fastest of any wind tunnel in the country with test sections more than 2 ft. in diameter, the new Boeing experimental laboratory can produce gales in the 700 mile-an-hour range, approximating the speed of sound, through its 12-ft. wide test section.

The new tunnel is a self-contained research unit, complete with model design



Photos courtesy Austin Co.

Fig. 1

This artist's cutaway drawing of the new Boeing wind tunnel shows the power unit operations room and office quarters as well as the tunnel itself. Noteworthy features which can be seen include the power substation, giant motor and clutch, large fan with hub fairing, air interchanger tower, turning vanes and test section. It is one of the most complete, modern tunnels in existence.

The welded steel pressure cap closes the tunnel bore in the area circled. At that point, a pressure of 1000 lb. per square foot inward is developed by operation with wind velocities which reach 700 mph. in the steel-encased test section. The skin of the cap, itself, is $^{3}/_{16}$-in. plate, reinforced with tees and placed at approximately 18 in. on center.

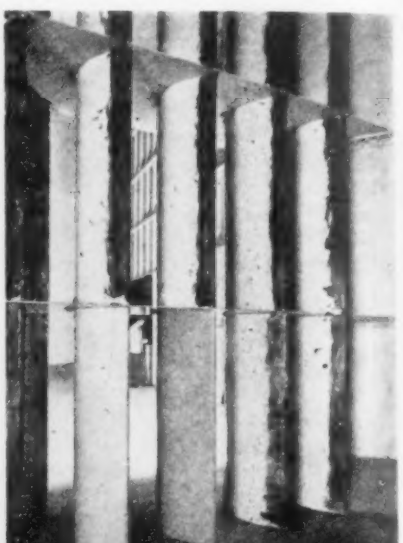


Fig. 2

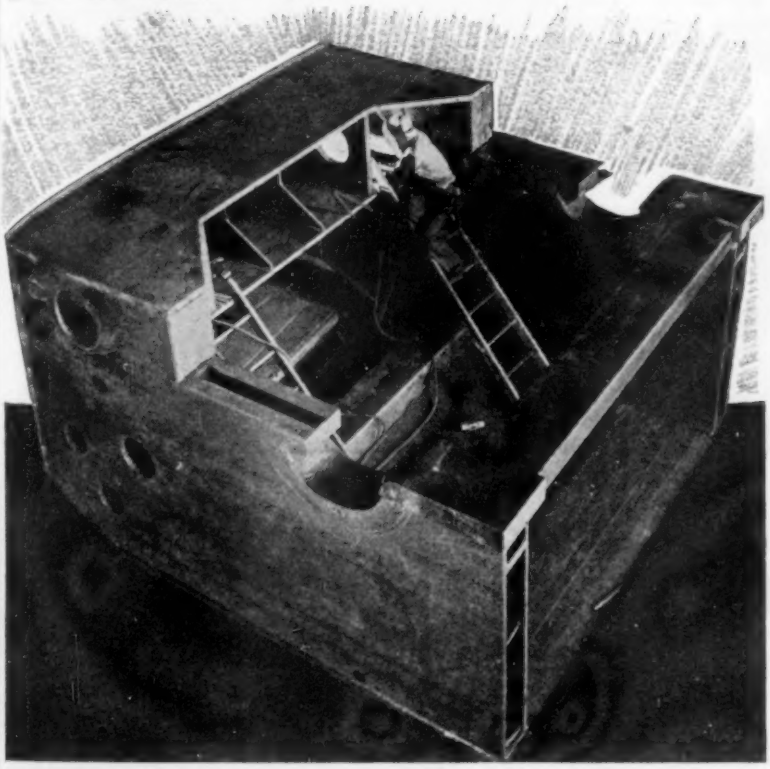
The close-up view of "turning" vanes installed at each of the four corners of the 450-ft. rectangular bore in the new Boeing wind tunnel illustrates the construction of these units which guide the air flow in a manner which eliminates turbulence and produces maximum wind velocity. Cold water circulating in pipes that extend through these vanes removes the heat generated during high-speed operation of the tunnel.

The vanes, themselves, were fabricated from ingot iron and were installed in an adjustable fashion, but will be welded into permanent position after the completion of test to determine just what angles will produce the most successful results.

THE POSTWAR WORLD is going to see the production of many new, high-strength alloy steels. This means new arc welding electrodes to meet the new metallurgical requirements.

As in the past, Metal & Thermit intends to be ready and whenever one of these new rods is required, there will be a Murex Electrode to meet the demand.

THIS COUPLING SHAFT, used by Caterpillar Tractor Co. in a running-in stand for testing Diesel engines, is subject to extreme tension and torsional stresses. In case of breakage, it is repaired with Murex Electrodes because of the high tensile strength and excellent physical properties of the weld metal.



HUGE BENDING PRESSES, manufactured by The Cleveland Crane and Engineering Company, have bending capacities up to 220 tons. All-welded frames, fabricated with Murex Electrodes, have greater strength and rigidity for weight of metal used than is possible by any other method. A feature of the design is that distortions and strains are not concentrated but are absorbed by frame as a whole.

CRAWLER FRAMES of high speed tractors are welded with Murex Genex Electrodes by International Harvester Company. Positioning enables the frames to be tilted to the most advantageous angle for each operation.

WHEN WORK cannot be positioned and where welds of good quality must be made overhead, specify Murex Vertex Electrodes. A combination gas and slag shielded rod, Vertex induces flat or slightly convex fillets. Uses D.C., reverse polarity.

Send for your copy of the new Murex Wall Chart, a guide to the right electrode to use for the job. Also contains application data and physical properties.

MUREX

ARC WELDING ELECTRODES

•

METAL & THERMIT CORPORATION

120 Broadway, New York 5, N. Y.

ALBANY • CHICAGO • PITTSBURGH
SOUTH SAN FRANCISCO • TORONTO

Specialists in welding for nearly forty years. Manufacturers of Murex Electrodes for arc welding, and of Thermit for repair and fabrication of heavy parts.

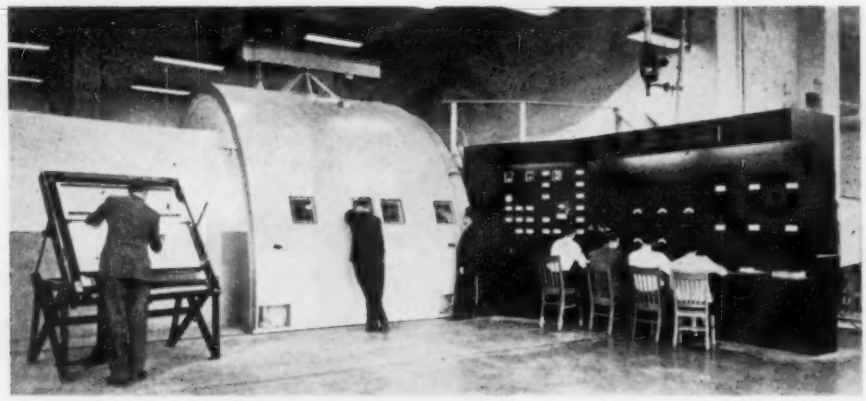


Fig. 3

Control and observation facilities for the world's fastest, large wind tunnel recently completed by The Austin Co. for Boeing Aircraft Co. in Seattle are concentrated in this area, alongside the welded steel pressure cap which incloses the critical test section. Controls and automatic recording instruments are included in the large instrument panel on the right. The pressure cap seen in the center has four observation windows at eye level. It is mounted on rollers and equipped with push button controls which move it back and forth to give access to the test area.

and construction facilities and computing laboratories, as well as actual testing quarters. It has numerous experimentation conveniences and refinements never before built into any single tunnel, and is streamlined for efficiency of operation.

The tunnel bore is a complete, continuous-return structure which follows an approximately rectangular course 450 ft. in length. It varies in size from 8 x 12 ft. in the "throat" or test section to $27\frac{1}{2}$ x $27\frac{1}{2}$ ft. at the largest part.

Employment Service Bulletin

SERVICES AVAILABLE

A-472. Fourteen years' experience in the welding field as welder, government instructor, foreman and welding engineer on all types of welded fabrication. Desires position in the supervisory class preferably to head up a welding department for a large organization or as welding engineer.

A-478. Welding Engineer. Young man with a prominent record of achievement in welding seeks wider scope and opportunities for his abilities. Broad experience in engineering development, radiographic inspection, jigs and fixtures and production in the welding industry. Interested in designing and development of products for welding.

A-479. Young man, 31, married, desires change to engineering or development work. Background includes 7 years' manual applications of electric arc and oxyacetylene welding in construction, shipyard, ship repair and paper mill maintenance. Education includes ESMWT courses in Welding Engineering and

Attention!

WELDERS ENGINEERS
CONTRACTORS
R.R. MAINTENANCE MEN

Manganal Exposes Big Money Waste.

Get Your FREE Copy of the

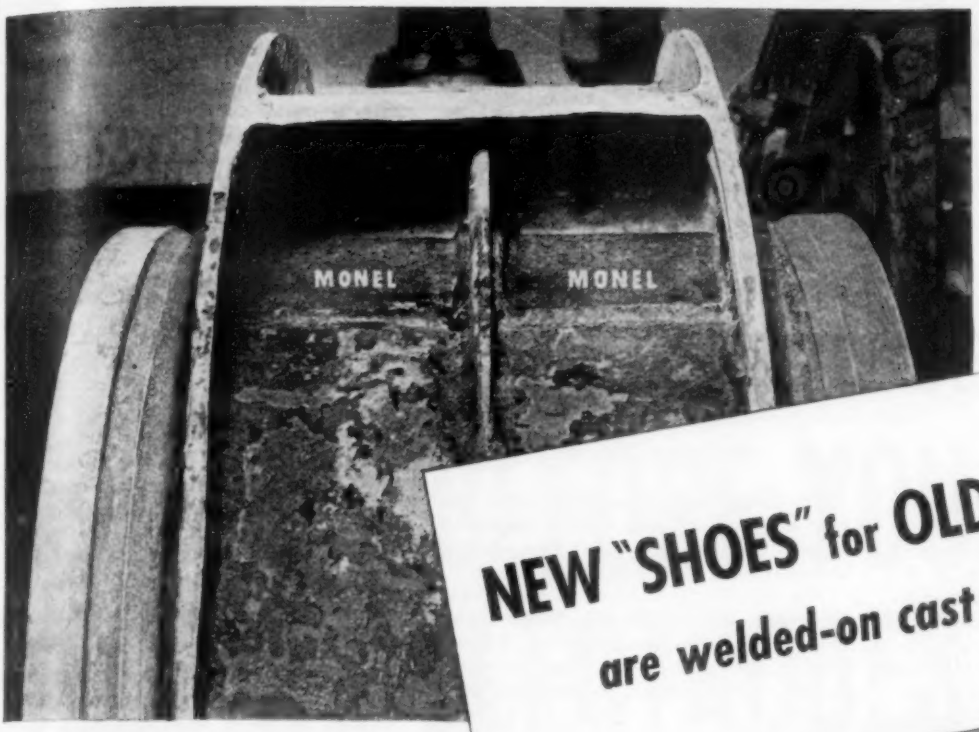
WELDERS GUIDE, sensational all-purpose newspaper. It also contains a beautiful photograph of

The Welders Pin Up Girl

Write For It Today

STULZ-SICKLES CO.

255—9th St., San Francisco 3, Calif. **134 Lafayette St., Newark 5, N. J.**



NEW "SHOES" for OLD PUMPS

are welded-on cast Monel

CLOSE-UP OF WELDED MONEL "SHOES" on impeller vanes of large salt water pump in the Long Branch plant of Southern California Edison Co., Ltd. While some welds show cavitation after two years' exposure to swiftly moving sea water, the Monel patches remain relatively smooth and fit for long additional service.

This "shoeing" job has stood a lot of stiff service.

It's helped keep essential equipment at work in the Long Beach plant of the Southern California Edison Company, Ltd.

Large pumps are used in the plant to circulate salt water as a cooling medium. The pumps, in service for almost 17 years, are each capable of handling 50,000 gallons of sea water per minute, and operate at 296 r.p.m.

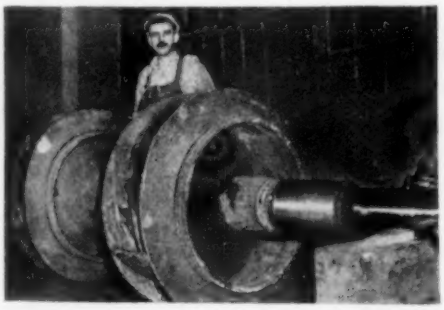
The 48-inch manganese bronze impellers are exposed to salt water moving at high speed. The original impeller vanes long ago gave in to corrosion and cavitation.

At first, repairs were made with shoes, or patches, of bronze. These failed.

Then, over two years ago, new shoes of cast Monel were welded in as replacements on one impeller. Since that time, the impeller has given no trouble. Although some welds showed the effects of cavitation when examined a few months ago, the shoes are relatively smooth and appear ready for many years more service.

Recently, the second impeller was also fitted with welded Monel shoes. As the shoes must be shaped to the contour of the vanes, standard Monel castings with relatively low silicon content were used.

Monel not only welds readily, but both the weld and the repair part *last*. Where a metal that combines strength, toughness and corrosion-resistance is needed to keep war-essential equipment at work, here's a reliable suggestion: *use Monel.*



TWO 48-INCH IMPELLERS, of manganese bronze, handle 50,000 gallons of sea water per minute in each pump. Welded Monel shoes proved so successful in one pump that similar patches were recently applied to the impeller vanes of a second large pump.

INCO NICKEL ALLOYS

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK 5, N. Y.

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL • Sheet ... Strip ... Rod ... Tubing ... Wire ... Castings

Strength of Materials. Laboratory aptitude test results available.

A-480. Licensed Professional Engineer N. Y. State; graduate of Cornell. Well-rounded background of experience in welded steel fabrication in office, shop and field. Qualified for position as Welding Engineer, Plant Engineer, Designer and Estimator of Welded Steel Products. Shop experience—three years as Plant Engineer, Welding Engineer, on welded steel fabrication. Developed welding procedures, etc., installed automatic welding production line and developed technique for same, designed shop improvements. Familiar with machine shop practice. Office experience—two years in design and detailing of welded structural steel. Field experience—one year as inspector and supervisor of welded steel construction. Graduate of New York Trade School. Devised and gave course in structural welding for group of engineers, also course in blueprint reading for shop employees. Salary approximately $6000 a year depending on location, responsibility, etc.

SECTION ACTIVITIES

BRUNSWICK

Organizational meeting of the Brunswick, Ga., Section was held on May 22nd at the Mark Carr Hall. Wiley P. Bolen, Assistant Welding Superintendent, J. A. Jones Construction Co., Inc., was toastmaster. Introduction was in charge of Emil J. Kratt, General Manager, J. A. Jones Construction Co. J. Lyell Wilson, Assistant Chief Surveyor, American Bureau of Shipping, was the principal speaker and his address and anecdotes were well received by the 243 members and guests present.

The following officers were installed at this meeting: W. A. Pierre, Jr., *Chairman;* R. L. E. Cook, *Vice-Chairman;* W. P. Bolen, *Secretary and Treasurer.*

CHICAGO

The Chicago Section held its final meeting of the 1943–44 season Friday, May 19th. The speaker of the evening was Roy Norton, Manager of the Welding Division, Ampco Metals, Inc., Milwaukee.

Mr. Norton discussed welding of aluminum bronzes. In an illustrated talk he pointed out the many uses that were being made of aluminum bronze at this time, and also told of probable uses of this highly versatile material which are likely to come about after the war. While aluminum bronze cannot be considered a cure-all for all welding applications it possesses many possibilities. Following his presentation was a question and answer period which brought out many details regarding applications, engineering properties and other pertinent factors regarding the various aluminum processes available for welding.

The 1944–45 officers and directors of the Chicago Section who were elected were also announced at this meeting. The new officers are C. L. Pfeiffer, Western Electric Co., *Chairman,* and C. G. Bassler, The Taylor-Winfield Corp., *Vice-Chairman.* T. B. Jefferson, *The Welding Engineer,* was re-elected Secretary. New directors elected for a three-year term are L. U. Burgess, Whiting Corp.; John Plaskon, Metal and Thermit Corp.; J. M. Cooper, National Electric Welding Co.; and Jim Quigley, Graver Tank and Mfg. Co. E. P. Auler, Taylor Forge and Pipe, was elected director for one year to fill an unexpired term. C. J. McGregor, American Steel and Wire Co., was re-elected director-at-large.

FLINT

The annual meeting of the Flint group held on June 3rd was a most successful affair. One hundred thirty-two couples attended and a good time was had by all.

The election results were as follows: *Chairman,* W. B. Spurling, Fisher Tank Div.; *Vice-Chairman,* Howard Rogers, Fisher Body Unit No. 1; *Secretary,* H. B. Mills, Buick Motor Division; *Treasurer,* Adam T. Smith, U. S. Ordnance Dept. *Executive Committee:* E. A. Fisher, W. F. Wiley, V. S. Fegley, Stuart Spice, R. J. Heusel, G. Burrows.

INDIANA

The Indiana Section held its April meeting at Cifaldi's in Indianapolis. The speaker of the evening was Mr. George N. Sieger, District Vice-President of the AMERICAN WELDING SOCIETY and President of the S-M-S Corporation of Detroit, Mich.

Mr. Sieger presented a most interesting and enlightening talk on the topic of Resistance Welding. The members and visitors unanimously agreed that it was thoroughly informative and enjoyable.

A United States Navy film on Resistance Welding was shown, with special narration covering many details and highlighting important points throughout the film. Other sections should put this Navy film on their "Must See" list as it has great value.

The entire program consumed three hours and was considered one of the best meetings this year; the attendance totaled sixty-nine.

Annual election of officers was held at the May 25th meeting. The following were elected for the coming year: *Chairman,* J. R. Wirt; *1st Vice-Chairman,* W. G. Morgan; *2nd Vice-Chairman,* George Mann; *Treasurer,* Paul Grubbs; *Secretary,* (Mrs.) Mercedes Spots, P. R. Mallory and Co.

The meeting was addressed by Mr. W. R. Baker, Manager and President of Una Welding, Inc., Cleveland. Mr. Baker spoke on "Types and Methods of Automatic Welding."

KANSAS CITY

The Kansas City Section held its May meeting on the 9th at Fred Harvey's Pine Room.

The guest speaker of the evening was Walter J. Brooking, Director of Testing and Research, R. G. LeTourneau, Inc. Mr. Brooking spoke on the subject, "Control of Arc Welding for Mass Production of Heavy Grading Machinery." So that the audience would have a clear understanding of the equipment produced by R. G. LeTourneau, Inc., and the terrifically hard usage this equipment receives, he preceded his talk with a portion of two movies produced by the United States Army Engineers, demonstrating the use of these ingenious earth-moving machines.

Mr. Brooking's talk concerned the procedure control problems that confronted this concern and how they were overcome. He also pointed out how the cost of the manufacture of this or any equipment can be greatly reduced by the use of proper arc-welding procedure technique and control of the process. His various points were graphically illustrated by means of slides and his talk was very interesting and highly informative to the members and guests present.

The newly elected officers (listed below) for the 1944–45 season were announced and introduced to the assemblage, after which the meeting was adjourned until September.

Chairman, D. Duane De Brunner, Columbian Steel Tank Co.; *Vice-Chairman,* Russel R. Fitch, Aluminum Company of America; *Secretary-Treasurer,* A. C. Sluss, Moore Co. *Directors:* R. W. Brigham, John W. Gustaveson, James H. Tarbell, George Mika, Carl Schmidt, G. F. Williamson.

LEHIGH VALLEY

At a special meeting of the officers and directors of the Lehigh Valley Section held on June 5th, it was decided to continue holding the monthly meetings on the first Monday of the month at the Hotel Bethlehem. The first of seven meetings will be held on October 2nd. The technical meeting will begin at 8 o'clock and will be preceded by a dinner at 6:45. Some the subjects which will be programed are Weldability, Jigs and Fixtures, Flame Cutting, Steel Castings and Mechanical Design. Also a Panel Discussion Meeting will be scheduled.

LOUISVILLE

The seventh monthly meeting of the

IMMEDIATE
STOCK SHIPMENTS
ON MOST TYPES

BEFORE YOU ORDER WELDING ELECTRODES . . . .

consult Westinghouse

Westinghouse is pleased to announce greatly improved deliveries on electrodes . . . immediate stock shipment on most types.

Among those immediately available is the new ACP electrode which is definitely superior for all-position a-c or d-c reverse-polarity work. While this electrode has been in production and use for considerable time, its announcement to the trade has been withheld pending the building up of present substantial stocks. (See current trade papers for formal announcement.)

Also available for shipment now is the famous DH electrode for high-speed, horizontal fillet and flat welds where high quality is essential. Likewise ready for quick delivery are standard AP (d-c) and FP (a-c or d-c) electrodes.

Wire or phone your nearest Westinghouse office for complete details and definite shipping data. Westinghouse Electric & Manufacturing Company, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-90536

WESTINGHOUSE PRESENTS—*JOHN CHARLES THOMAS—SUN. 2:30 E. W. T., N. B. C.—"TOP OF THE EVENING"—MON. WED. FRI. 10:15 E. W. T. BLUE NETWORK*

Westinghouse
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

WELDERS · ELECTRODES AND ACCESSORIES

Louisville Section was held in the auditorium of the Speed Scientific School, University of Louisville, Monday, April 10th. Due to an unexpected serious illness in the family of the scheduled speaker, Harry W. Pierce, Assistant General Manager, New York Shipbuilding Corp., Camden, N. J., canceled the trip to Louisville, Ky.

Mr. Harrington C. Powers, Welding Supervisor of American Air Filter Co., Inc., Louisville, graciously accepted the invitation to substitute and use the original speaker's theme, "Arc Welding Sequences of Ship Hulls." Mr. Powers presented his talk with six welded specimens. He demonstrated that by using the proper technique unnecessary warping was eliminated. Open discussion then became very interesting.

Mr. A. L. J. Gillette, Flight Instructor at Bowman Field, Ky., was formerly Welding Engineer and Head Welding Instructor at Jeffersonville Boat and Machine Co., Jeffersonville, Ind. He gave an interesting talk on the "Formula for Electrode Coatings and Their Uses." Having been associated with John A. Roebling's Sons Co., Trenton, N. J., in research and laboratories, he was well qualified to speak on the subject.

Mr. Harry A. Acy gave a ten-minute talk on Welding Technique from an engineering standpoint. He pointed out that the welding foreman and superintendent should have work sheets outlining welding procedure, size of weld, etc. He feels that in time most of the plants where welding is employed will use work sheets. To illustrate his point he passed a number of work sheets out to the audience.

The visitors from Missouri Valley Shipbuilding Co., Evansville, Ind., enlivened the meeting with their questions. Announcement was made of the death of Ben I. Whener, Old Time Welding Shop, Owner. The meeting minus the dinner was very interesting. The meeting was adjourned at 11 P.M.

MARYLAND

The following are the elected officers and committeemen of the Maryland Section for the 1944–45 season: *Chairman*, J. C. Cumberland; *Vice-Chairman*, J. H. Humberstone; *Secretary-Treasurer*, W. H. Shaprow. *Executive Committee:* A. C. Earlbeck, R. C. Fitzgerald, Bela M. Ronay, J. W. Gore, C. N. Hilbinger.

The May 19th meeting was based on an annual members' forum. Three members spoke, each giving a twenty-minute talk with from fifteen to twenty minutes for discussion. The topics were:

"Welding of High-Pressure Piping," by R. C. Fitzgerald. Mr. Fitzgerald traced the development of the "Westport" joint, using slides to illustrate. This joint eliminates the chill ring by the method used in machining and rolling the ends to be joined.

"Maintenance of Spot-Welding Equipment," by W. H. Shaprow. This presentation stressed the necessity of proper equipment maintenance and pointed out those parts and mechanisms that need periodical inspection and care.

"Welding of Structural Steel," by Van. R. P. Saxe. Mr. Saxe has done much work in fostering the use of welding in the erection of steel. The talk was supported by slides showing many types of fabrication and various stages of buildings under erection.

Farewells were extended to Mr. Donald Darr, our retiring Secretary-Treasurer, who was to enter the Marine Corps during the following week.

Discussions were carried on over refreshments for nearly an hour. This meeting ends the current season. Activities will be resumed in October.

NEW JERSEY

Annual meeting of the New Jersey Section was held on May 19th at the Cedar Ridge Country Club, Livingston, N. J. Except for report of Tellers' Committee, no formal business was transacted. New officers for 1944–45 season were introduced; buffet supper was served at 9:00 P.M.; 112 members and guests were present in the evening; 177 tickets sold for golf in the afternoon.

NORTHWEST

The seventh annual meeting of the Northwest Section was held Thursday, May 18th, at 6:30 P.M. at the Covered Wagon, Minneapolis.

The meeting was devoted to better acquaintance and good fellowship among the members, 65 being present.

Brief annual reports were made by Secretary-Treasurer Alexis Caswell, showing that the Section was in a good financial position, and the membership larger than it has ever been, due to the leadership of Chairman John Mikulak.

The following officers and executive committee were duly elected: *Chairman*, C. M. Underwood, Northern Pump Co.; *Vice-Chairman*, Louis T. Kenny, Kenny Boiler and Mfg. Co.; *Secretary-Treasurer*, Alexis Caswell. *Executive Committee:* Walter V. Brown, C. M. Glogston, C. E. Comfort, Edgar E. Hall, E. L. Hixson, John Mikulak, R. H. Newton, Walter Sandquist, E. C. Schroeder, F. W. Scott, R. J. Stoddard, M. M. Weist, J. E. Williams.

OKLAHOMA CITY

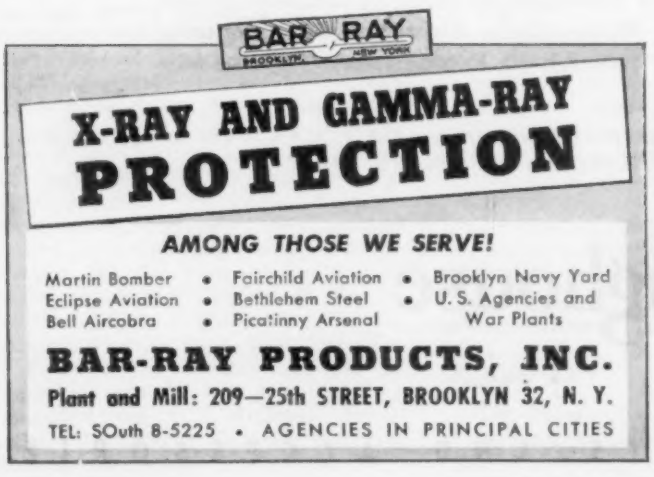
The Oklahoma City Section announces the election of the following officers and executive committee for the 1944–45 season: *Chairman*, H. N. Simms; *Vice-Chairman*, C. M. Bowen; *Secretary*, Jos. M. Mideke; *Treasurer*, Otto Hart. *Executive Committee:* W. D. Brewer, J. S Cook, W. S. Gleason, M. G. Wicker.

PHILADELPHIA

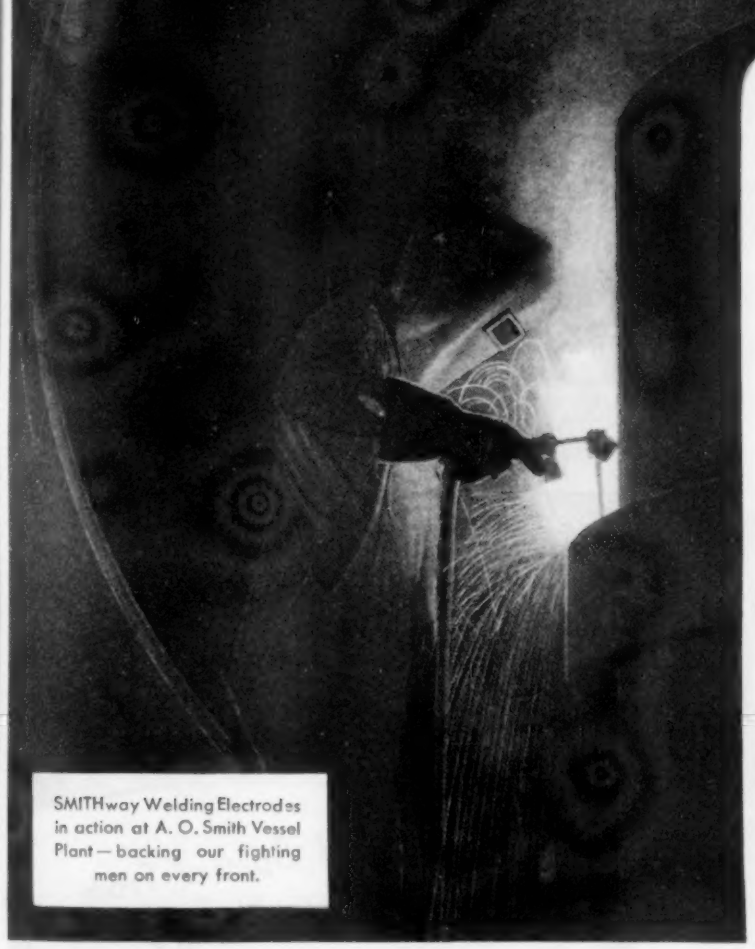
The final meeting of the season was held on May 15th at the Engineers' Club. R. F. Wyer, Application Engineer, Welding Dept., General Electric Co., spoke on the subject, "Some Developments in Gas Shielded Arc Welding." Mention was also made of the use of both helium and argon for shielding and the welding of magnesium, aluminum and stainless steels.

PITTSBURGH

The Seventh Annual Tri-State Convention of the Pittsburgh Section held jointly with the Engineers' Society of Western Pennsylvania was held in the auditorium of the Mellon Institute of Industrial Research Building, Friday night, April 28th, at which time Mr. Roy W. Emerson,


BAR RAY
BROOKLYN NEW YORK
X-RAY AND GAMMA-RAY
PROTECTION
AMONG THOSE WE SERVE!
Martin Bomber • Fairchild Aviation • Brooklyn Navy Yard
Eclipse Aviation • Bethlehem Steel • U. S. Agencies and
Bell Aircobra • Picatinny Arsenal War Plants
BAR-RAY PRODUCTS, INC.
Plant and Mill: 209—25th STREET, BROOKLYN 32, N. Y.
TEL: SOuth 8-5225 • AGENCIES IN PRINCIPAL CITIES

320,000 SHOP-TESTED *Every Day*



SMITHway Welding Electrodes in action at A. O. Smith Vessel Plant—backing our fighting men on every front.

MORE than 320,000 SMITHway Certified Welding Electrodes are *shop-tested and proved* in our own production *every day.*

Here is the count for an average day's work in Smith plants:

- 17,620 stainless steel electrodes of various compositions,
- 107,900 high tensile electrodes of different strengths and alloys,
- 195,020 mild steel electrodes of all types.

And because they're *shop-tested,* you can depend on SMITHway Welding Electrodes when you're up against a tough production schedule.

With us, welding electrodes are production tools. We *must* have unvarying uniformity in the characteristics of the electrodes we use. Run-of-the-mine electrodes are not good enough to meet the acid tests of rigid cost control, high production rates and uncompromising inspection.

That's why we make our own. We offer you the same electrodes. And they can do for you what they've done for us—give you *better welds* at *lower welding cost.*

Mild Steel . . . High Tensile . . . and Stainless Steel
WELDING ELECTRODES

made by welders . . . for welders

SMITHway A. C. Welding Machine saves power; eliminates arc blow.

SMITHway Welding Monitor trains better welders faster.

A. O. SMITH Corporation

MILWAUKEE • WISCONSIN • HOUSTON • TEXAS

Offices at: NEW YORK, PITTSBURGH, CHICAGO, TULSA, HOUSTON, LOS ANGELES, SEATTLE

In Canada—JOHN INGLIS CO., LIMITED

Metallurgist, Pittsburgh Piping and Equipment Co., gave a most interesting discussion on "Fundamentals of Welding."

The address of welcome was given by Dr. W. N. Jones, Director, College of Engineering, Carnegie Institute of Technology, who is president of the Engineers' Society of Western Pennsylvania.

Previous to the meeting a most enjoyable "Get-Together" Dinner was held in the Hotel Webster Hall, at which time a Coffee Talk was given by Dr. A. A. Bates, Manager, Chemical and Metallurgical Division, Westinghouse Electric and Manufacturing Co., on the subject of "South America."

The Pittsburgh Section was especially honored by the presence of Miss M. M. Kelly, Secretary of the AMERICAN WELDING SOCIETY, who was introduced to the members and guests at both the dinner and evening meetings. Mrs. Charles H. Jennings, wife of the Section Chairman, served as companion to Miss Kelly for the occasion.

SAN FRANCISCO

The April meeting of the San Francisco Section was held at Angelo's Ball Room, Emeryville. There were approximately 75 members and guests present.

The election of officers for the fiscal year was announced as follows: *Chairman*, C. F. Doggett, Moore Dry Dock Co.; *Vice-Chairman*, Leo Berner, Joshua Hendy Iron Works; *Treasurer*, H. W. Saunders, Air Reduction Sales; *Secretary*, R. E. Lebagh, Victor Equipment Co.

The meeting was addressed by Mr. Ted Nelson of the Nelson Specialty Welding Equipment Co., who presented a talk on Stud Welding. Mr. Nelson's résumé of the development of the stud welder, present uses and potential application was very interesting and enlightening.

SYRACUSE

The ninth regular meeting of the Syracuse Section was held May 11th at Kupperman's Restaurant. The purpose of the meeting was to announce the annual election of officers and allow the members an opportunity to get together for a good time.

The evening's entertainment was introduced by the toastmaster, Raymond Malvin of Fitzgibbons Boiler Works. Highlight of the evening was the experiments in thought transference carried out by Mr. Solomen, a local executive, whose hobby is sleight of hand. Another feature was the exhibition of juggling presented by Mr. Lynch.

The following officers and Section directors were re-elected: *Chairman*, J. Kielb; *Vice-Chairman*, J. Roscoe; *Treasurer*, A. Cassel; *Secretary*, J. Hotchkiss. *Section Directors:* H. Reynolds, R. J. Greer, J. D. Lannon, C. T. Patterson, J. W. Holton, H. C. Harr.

On June 8th the Section was invited on a tour of inspection by the Fitzgibbons Boiler Works in Oswego, N. Y. The tour was from 3:00 P.M. to 5:00 P.M., after which the members dined at the Hotel Pontiac.

TOLEDO

Mr. J. A. Farrell, Service Engineer, Detroit Office of The Linde Air Products Co., was the guest speaker at the May 16th meeting. Mr. Farrell's subject was "Oxyacetylene Process of the Welded Sheet Metal Fabrication, Pertaining to Stainless Steel, Aluminum, etc." Slides were shown giving details on hand, as well as automatic machine welding. An extra feature was the automatic continuous method of forming and gas welding of stainless steel tubing in a Yoder Mill. A film was also presented showing the technique of the Unionmelt process.

During the question and answer period which followed, the speaker elaborated on many details.

WESTERN MASSACHUSETTS

The April 24th meeting was held in the auditorium of the Westinghouse Electric and Manufacturing Co. Springfield, Mass. Mr. A. K. Phillippi, Manufacturing Engineer at the Westinghouse Co., gave a very interesting and informative talk, which was really a sequel to his talk earlier in the season on furnace brazing. He covered furnace atmospheres, and equipment for obtaining such atmospheres. Numerous

Spray or brush PROTECT-O-METAL into seam and upon adjacent surfaces. There's less spatter with PROTECT-O-METAL and remaining globules bounce off of inclined surfaces. Those resting upon a horizontal surface don't adhere; easily wiped off. PROTECT-O-METAL in seam improves the weld—makes it less porous, hence stronger—quiets the arc—improves fusion of weld metal with parent metal. Absolutely no fumes or odor. PROTECT-O-METAL gives better bond for paint. Contains deoxidizing agent which prevents rust. A gallon of PROTECT-O-METAL thinned with water makes 2 to 3 gallons of mixture. Order trial gallon @ $3.00 f.o.b. nearest shipping point. Satisfaction or no pay.

G. W. SMITH & SONS
110 Sperling Ave., Dayton 3, Ohio

Is this YOUR Cleaning Problem?
Keep Weld Spatter From Sticking to Surface
By simply brushing or swabbing a solution of the recommended Oakite material over the surface surrounding the area to be welded, you can effectively prevent weld spatter from adhering to the metal in arc, flash or butt welding. No need for grinding or chipping off.
This successful, economical Oakite method saves time and manual effort formerly required on this work. Complete details are FREE on request.
OAKITE PRODUCTS, INC., 18E Thames St., NEW YORK 6, N.Y.
Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada
OAKITE
Tools Forged for Victory
CLEANING
MATERIALS · METHODS · SERVICE

JOIN METALS FASTER, BETTER

with High Frequency Induction Heating

Many production metal-joining operations now performed by welding or brazing can be done with remarkable savings of time and cost by modern Lepel High Frequency Induction Heating. The most intricate jobs can be so simplified that they can be accomplished in a matter of seconds by

1. Assembling pre-fluxed parts (in jigs if necessary) with the brazing alloy pre-formed in the form of rings, strips or irregular shapes.
2. Heating the joint or seam by means of a "load coil" for the exact time necessary to insure thorough penetration by the molten alloy.

Brazing alloys of any melting point from the lowest to the highest can be used.

An entire joint of any shape — or several joints — can be heated at one time. Heating frequently can be performed on a moving belt in conjunction with other operations to provide continuous-flow production.

As the heat is generated within the metal itself, the brazing alloy penetrates throughout the joint, producing maximum strength and soundness. At the same time, accurate manual or automatic control of time and temperature cycles prevents excessive heating, minimizing discoloration and practically eliminating scale. Thus little, if any, cleaning up or refinishing is necessary.

A Lepel field service engineer will be pleased to call to give you further information and aid in working out details of the applications of this modern method to your joining operations.

LEPEL HIGH FREQUENCY LABORATORIES, INC.

PIONEERS IN INDUCTION HEATING

39 W. 60th STREET **NEW YORK 23, N. Y.**

pieces of furnace-brazed assemblies were shown and an extended discussion followed.

There were 45 members and guests present.

WICHITA

Officers elected by the Wichita Section for the coming year are: *Chairman*, R. L. Townsend; *Vice-Chairman*, E. A. Bussard; *Secretary*, M. L. Lampton; *Treasurer*, E. A. Hammer.

YORK-CENTRAL PENNSYLVANIA

This Section, holding its fifth annual dinner meeting on April 12th at the Alcazar Ball Room, achieved one of the most successful gatherings of technical men ever held. The meeting was attended by 450 members and guests. Companies and their executives from all surrounding towns participated.

Dr. W. G. Theisinger, Assistant to the Vice-President of Lukens Steel Co., was guest speaker. Dr. Theisinger's subject, "Research in Welding and Fabrication," covered the various materials and processes available for future welding and fabrication. Slides were shown covering the proper procedure and technique employed in welding clad steels. There was also a full-colored motion picture of the complete process in rolling clad steels, which was one of the most interesting pictures the Section has been privileged to see.

C. E. Lewis Kerchner

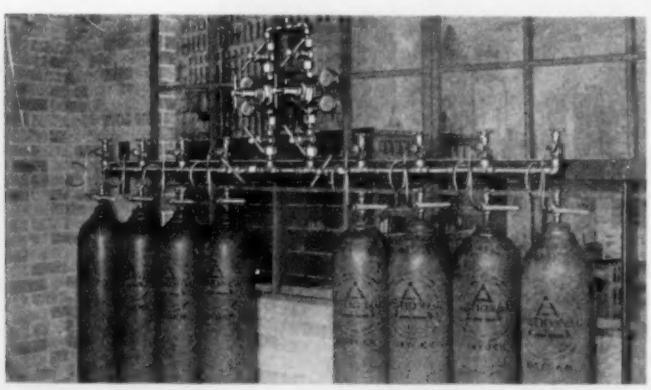
Also at this meeting there was quite an exhibit of weldments, all-welded jigs and fixtures of various types, which were displayed by various companies. These companies exhibited for the sole purpose of interchanging ideas, in order that welders, operators and technical supervisors might profit by the experience of others. This type of cooperation between companies and technical societies throughout this Section has been one of the main factors in the success of the York Plan, which, originating here, has now spread throughout the country. Through the SOCIETY, and the exchange of ideas of technical men in the SOCIETY, the toughest welding problems in this Section have been licked; and the SOCIETY extends the invitation to all other societies or companies to submit any difficult welding problems for discussion.

Congratulations are in order to Mr. E. E. Rouscher, *Chairman*, and to his officers, for the great job they have done this past year and for the revival of interest they have aroused throughout this locality.

The York-Central Pa. Section held its final meeting of the season on May 10th at which time the following officers were elected for the coming season: *Chairman*, C. E. Lewis Kerchner, Southern Oxygen Co.; *Vice-Chairman*, Wm. Baur, York Safe and Lock Co.; *Secretary*, Paul Dressel, Dressel Spring Works; *Treasurer*, Charles Allen, York Safe and Lock Co.

Mr. Kerchner, the newly elected Chairman, has served faithfully as Secretary to the Section and has been one of the spark plugs in its success. Plans are now in the making for a more successful and interesting season.

Mr. Norman G. Schreiner of The Linde



BRASS MAKES BULLETS

REGO Gas Plant Equipment to be safe, must be made of brass and other critical metals.

Conserve your equipment. You may not get more.

The BASTIAN-BLESSING Co.
4241 W. PETERSON AVE. CHICAGO
Pioneers and Manufacturers of Precision Equipment for Using and Controlling High Pressure Gases

Save Time and Labor Costs:
Cut Down Fumes 30%:
Protect Metal Against Rust:
Get Unimpaired Welding Strength:
Do Cleaner Better Work—with

NO-SPAT

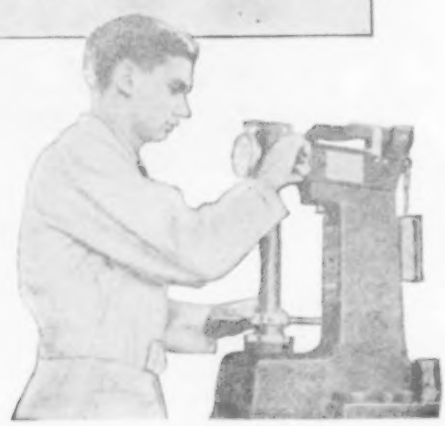
The Welding Fluid that Is Non-Toxic

NO-SPAT prevents welding spatter from adhering to metal surfaces—Unbiased scientific tests show NO-SPAT maintains maximum weld strength—reduces fumes 30%, is non-toxic—does not produce carbon monoxide.

NO-SPAT requires no mixing — apply and start welding at once. No time wasted.

THE MIDLAND PAINT & VARNISH CO.
9126 RENO AVENUE CLEVELAND 5, OHIO

The Most Important Thing
To Look for
in Resistance Welding Electrodes
is Something You Cannot See . . .



Quality Control . . . for the Right Alloy, Correctly Produced

Prescribing the proper electrode alloy for a specific welding job is important. Even more important is the ability to make that alloy so that its composition never varies in process of production.

Here at Mallory we have mastered the art. We know how metallurgical processes affect our alloys. We know what physical and electrical properties they impart. And we duplicate them again and again through a rigid system of quality control.

This thorough and scientific regulation starts with the raw materials. It continues through every detail of operation to the finished tip, roll or die. It follows the finished product into your plant, checking on performance in actual operation. It includes hundreds of sample melts in experimental furnaces, Rockwell tests for hardness, microscopic examinations for grain size, repeated alternating stresses in fatigue machines, elastic limit determination, exact measurements of tensile strength, electrical and thermal conductivity.

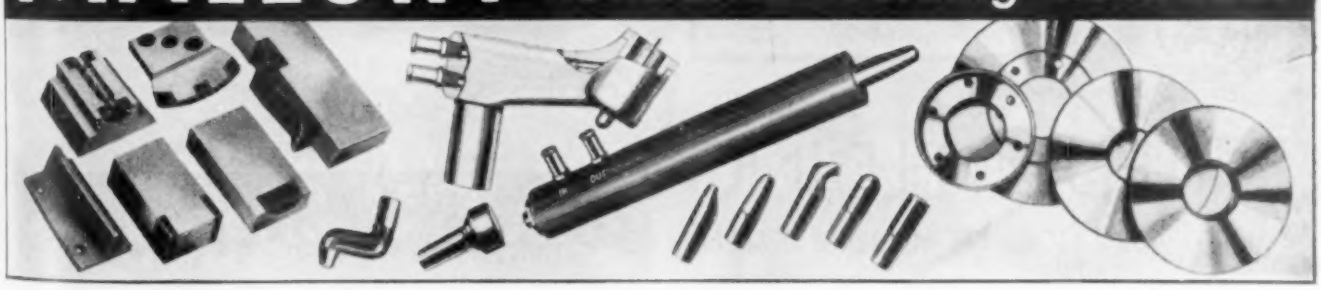
With such attention to detail, it is possible for you to establish high speed set-ups and procedure which, once fixed upon, require little if any change. Write today for specific data.

Make Your Dollars Fight — Buy More War Bonds

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

P.R. MALLORY & CO. Inc.

MALLORY *Standardized Resistance Welding Electrodes*



Recent Dinner Meeting York-Central Pa.

Air Products Co., Philadelphia, the speaker, covered the field of the Unionmelt process as applied to the welding field. With his talk were numerous slides and a full-length film showing the actual operation and the technique employed with welding of this type. Also, as in the past, there was an interesting exhibit of new design in weldments. These exhibits have been an interesting feature of the 1943–44 season and were an excellent medium for an exchange of ideas and an aid to furthering the welding program.

With the new officers in charge and the plans now being devised, the Section is looking forward to a banner year.

WELDING POSITIONER

Complete description and specifications on P & H's recently announced low-cost model WP-2 welding positioner are given in a bulletin released by the manufacturer. The unit, rated at 2500 pounds maximum, in the standard model, is also shown with handwheel rotation, and with motorized table turning. For the power-operated model, other available equipment includes remote control for table rotation, with either a full-magnetic push-button station or foot control. Both controls may be had with single or variable speed. Table tilting on all types is by manually-operated hydraulic action with a tilting range to 135 degrees beyond horizontal. Other features are easy elevation, positive locking devices on table tilt and turn, and two types of floor mountings. A comparison chart shows how welding time efficiency is increased when work is positioned to the best advantage. For copy of this bulletin, No. P2-1, address Welder Division, Harnischfeger Corporation, Milwaukee 14 Wisconsin.

Annual Meeting
Cleveland
Oct. 16-19
Hotel Cleveland

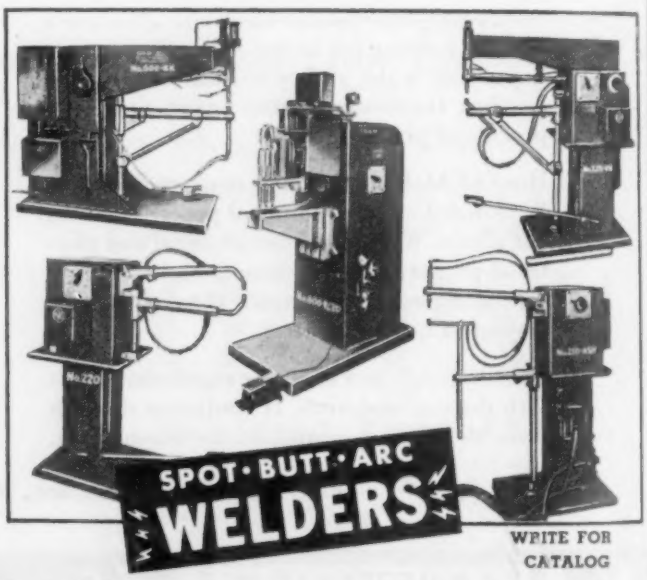
SERVICE ON FABRICATED WELDMENTS

Parts up to many tons welded and shipped with dispatch from private rail siding. Thousands of tons of diesel engine frames alone fabricated for war program.

Specialists in styling of machine tool bases, frames and housings. Submit your drawings. Difficult assignments particularly invited. No obligation.

THE UNITED WELDING CO.
MIDDLETOWN, OHIO

UNITED WELDING
WELDING FABRICATORS OF MODERN DESIGNS



WRITE FOR CATALOG

We manufacture a complete line of resistance spot welders from ¼ to 300 KVA for all types of welding. There is an EISLER WELDER for every purpose.

TRANSFORMERS OF ALL TYPES

WE INVITE CONTRACT SPOT WELDING IN LARGE OR SMALL QUANTITIES.

CHAS. EISLER
EISLER ENGINEERING CO.
779-SO. 13th ST. Near AVON AVE NEWARK, 3 N. J.

Parts built up with

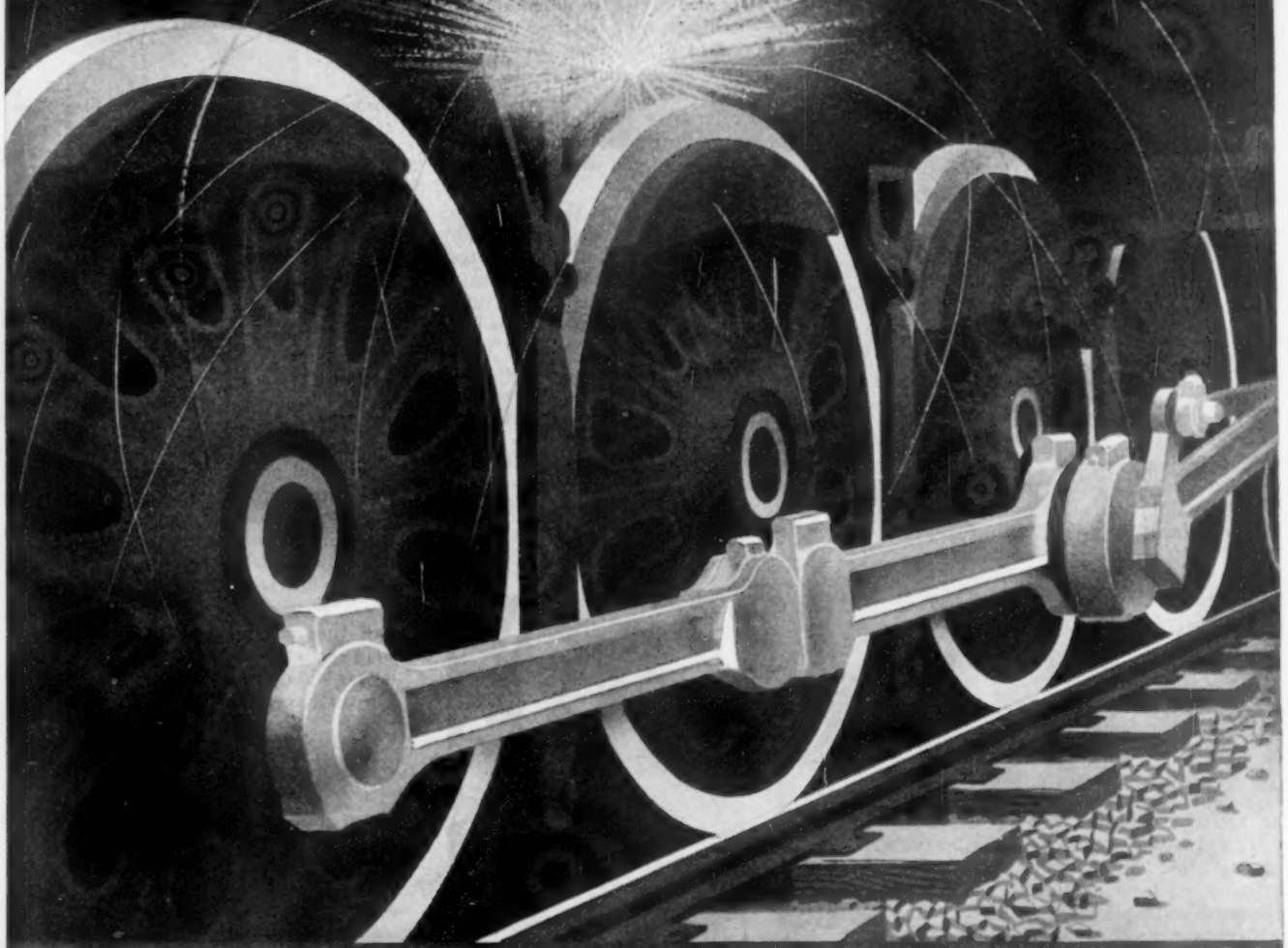
RACO 82 SHIELDED-ARC ELECTRODES

Stand up!

RACO 82 Shielded-Arc Electrodes are designed for building up worn parts and surfaces of medium-carbon steel. Best results are obtained with direct current, straight polarity, but satisfactory welds can be made with alternating current. Welds are machinable and can be bent cold or forged . . . RACO 82 Electrodes meet the requirements of U. S. Navy Specifications 46 E 3 (INT)—Grade EE.

Every RACO product owes its superiority to the twenty-five years experience that goes into its manufacture . . . quarter of a century devoted to constant improvement in materials, method and management.

Samples of RACO 82 Shielded-Arc Electrodes will be sent upon request.



The REID-AVERY COMPANY

DUNDALK BALTIMORE 22 MARYLAND

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

HANDY MACHINE GAS CUTTING GUIDE OFFERED

Air Reduction, manufacturers of gas- and arc-welding equipment and supplies, are offering a free pocket-sized, slide-type guide that shows proper tip sizes, gas pressures and other data required for machine gas-cutting steel of various thicknesses, with two of Airco's most widely used machine gas-cutting tips—Airco "45" and "124."

By setting the slide to one of the known factors—such as steel thickness—the gas-cutting machine operator may immediately determine the correct tip size to use, oxygen and acetylene pressures required, estimated gas consumption, width of kerf and average cutting speed to be expected. The back of the guide lists helpful hints for machine gas-cutting operators, including pointers on setting up, piercing starting holes, making heavy cuts, etc.

Free copies of this handy guide may be obtained by writing to the main office of Air Reduction, 60 E. 42nd St., New York 17, N. Y., or to any of the company's branch offices throughout the United States.

TURNBUCKLES

The revised Federal Specification for Turnbuckles FF-T-791 permits fabrication by welding in accordance with a design developed by H. L. Whittemore of the National Bureau of Standards.

A ROCKER ARM SPOT WELDER

A new rocker arm spot welder for production sheet metal work has been announced by Sciaky Bros., 4915 W. 67th St., Chicago 38, Ill. This relatively small unit employs features usually found only on larger machines. The upper arm is equipped with heavy duty roller bearings at the fulcrum point. The pressure cylinder contains a rubber bumper to eliminate hammering. The unit is entirely self-contained. Electronic controls and contactor are mounted in a hinged cabinet with dials and switches convenient to operator. Current interruption may be either magnetic or by ignitron tubes. Operation is fully automatic with controls for welding heat, duration of current, cool period and off period.

The welder is rated 30 kva. at 50% duty cycle with capacity on clean mild steel of from two thicknesses of 0.016 in. up to and including two thicknesses of 0.080 in. . . . stainless steel up to a maximum of 0.040 in. plus 0.040 in. Speed on two thicknesses of 0.032 in. pickled mild steel is 180 spots per minute. Electrode pressure at 24 in. throat depth is 1000 lb.

Write for Bulletin 112-A.

REPAIR OF ALUMINUM CASTINGS

A large percentage of the aluminum turret castings that previously had to be rejected because of porosity and hollow spots are now being repaired at The Glenn L. Martin Co., Baltimore, Md., by a new process evolved by Louis Barrett, Tool Design Process Engineer, in which the porous material is replaced with welding metal.

Under the new process the surface defects in the casting are first removed by grinding or chipping out the porous material. The casting is then preheated to 200 to 300° F. either in a furnace or by application of local heat. Next the cavity is welded or filled with weld metal using a carbon arc and a 5% silicon "Aluminum Weld" welding rod. Finally the welds are cleaned and filed smooth, and the weld area is neutralized.

The outstanding features of the new process are the preheating of the casting and the use of a carbon electrode in combination with the metal welding rod. The preheating simplifies the welding operation and lessens the possibility of cracks by lowering the temperature differential between the point of the weld and the surrounding metal. High heat at the point of weld is avoided. The use of the carbon electrode with a normal metal welding rod provides a better adhesion between the weld metal and the aluminum casting than when the metal welding rod is used by itself as an electrode.

The new method of repairing defective castings is limited in use to low-stressed areas. Porosity or hollow spots are determined by X-ray and following the welding, the casting is again X-rayed to insure a perfect blend between the weld metal and the casting.

Not only does the new method permit the rapid salvaging of castings that are urgently needed on the production line, but it is also resulting in the saving of considerable quantities of critical material, and the many man-hours that already went into the making of the casting before it was discovered to be defective by the Martin Receiving Inspection Dept.

Fig. 1

After the porous material has been removed by chipping or grinding, the area surrounding the cavity to be welded is preheated to 200 to 300° F. with a torch. A second man (in this picture Louis Barrett who devised the process) stands by ready to weld as soon as the required temperature is reached.

Fig. 2

The actual weld is made with a carbon electrode and a 5% silicon welding rod (Aluminum Weld), a method which was found to provide better blending of the metals than when the metal rod is used as an electrode.

WELDING FUMES

Self-contained packaged Westinghouse Precipitron units are increasingly being used to recover oil mists generated from coolants on machine tools and to control welding fumes and smoke.

OPTI-FLAT

The George Scherr Co., Inc., 200 Lafayette St., New York, N. Y. has issued a 4-page folder introducing the Scherr Opti-Flat, a new glass optically finished surface plate which is guaranteed flat to 0.00005 in.

What do you know about ELDING STAINLESS STEEL?

ccessful welding of Stainless Steel depends (1) the type and characteristics of the steel be welded, (2) the suitability of the elec- des used, and (3) *the skill and knowledge the welder.*

The first two factors are constant because e production of stainless steel, today, has ached a high state of perfection and . . . *ere is a type of* McKAY STAINLESS STEEL ELDING ELECTRODE, *with exactly cor- t characteristics,* for every stainless weld- g need.

The skill and knowledge of the welder, erefore, is of paramount importance! The re technical "know how" you have, the tter.

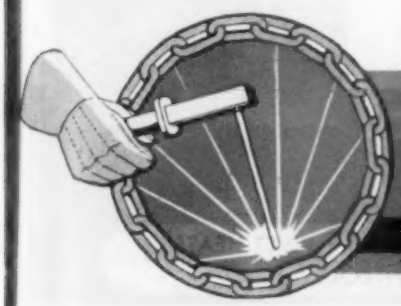
Can you answer the questions, listed at the ght, correctly . . . and give the reasons for ur answers? These and similar questions e discussed in a booklet soon to be released the McKAY COMPANY. It will contain, well, other data useful to every welder. It's ee. Reserve your copy today by writing for *Things to Know About Welding Stainless eel."*

DO YOU KNOW THE ANSWERS?

Test your knowledge with these 3 brain teasers. Then check the accuracy of your opinion by referring to the correct answers below. Space does not permit publication of the "reasons why" but full explanation may be found in the forthcoming McKAY booklet, "Things to Know About Welding Stainless Steel." Reserve your copy now . . . and watch for additional questions and answers in subsequent ads.

	TRUE	FALSE
1. *All Stainless Electrodes regardless of their manufacturing source or analyses, are coated with one or the other of two fundamental types of coating.*	☐	☐
2. *Compared with ordinary steels, Stainless Steels of the Chrome-Nickel type conduct heat about one-half as rapidly and expand twice as much.*	☐	☐
3. *Proper annealing practice for Chrome-Nickel Steels requires holding at 1900°F. for one hour for every inch of thickness, then furnace cool.*	☐	☐

Answers: (1.) True (2.) True (3.) False



General Sales Office: York, Pa.

THE McKAY COMPANY
PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

List of New Members

May 1 to May 31, 1944

BOSTON

Irwin, Stanley G. (C), 19 Riverbank Rd., No. Weymouth, Mass.
Linsky, Melvin E. (C), 83 Browne St., Brookline 46, Mass.
Miller, Barrie (C), Box 143, Edgewood Station, Providence, R. I.
Rainsbury, Charles E. (C), Eastern Appliance Co., 250 Stuart St., Boston, Mass.
Warren, Harold B. (A), Thomson-Gibb Electric Welding Co., 161 Pleasant St., Lynn, Mass.

CANADA

Chalmers, William (C), Spruce Falls Power & Paper Co., Ltd., Kapuskasing, Ont., Canada.

CANTON

Hill, Wayne Eldon (C), 26 E. Tallmadge Ave., Akron, Ohio.

CHICAGO

Babcock, H. L. (B), Graver Tank & Mfg. Co., E. Chicago, Ind.
Bergo, Michael A. (C), 3170 Pine Grove Ave., Chicago, Ill.

CINCINNATI

Feist, Alvin F. (C), 6949 Mulberry Ave., N. College Hill, Cincinnati, Ohio.
Myers, F. W., Jr., 1st Lt., T.C. (C), L. B. Harrison Club, Cincinnati, Ohio.

CLEVELAND

McCarthy, E. J. (B), 9919 Burton Ave., Cleveland, Ohio.
Nelson, Floyd J. (C), Box 173, Andover, Ohio.
Rowe, Arthur E. (B), 1900 Euclid Bldg., Cleveland 15, Ohio.
Scharf, Paul B. (B), 155 Elm St., Bradford, Pa.
Smith, Arthur D. (B), 3334 W. 98th, Cleveland, Ohio.
Speigle, Theodore James (C), 127 Grant St., Elyria, Ohio.

CONNECTICUT

Bozek, Walter (B), 139 Bradford Ave., Groton, Conn.

DETROIT

Adams, Henry C. (B), University of Michigan, Room 326, West Engrg. Bldg., Ann Arbor, Mich.
Colwill, J. H. (B), 14225 Kentucky Ave., Detroit 4, Mich.
Edmund, W. C. (B), 637 So. Edison, Royal Oak, Mich.
Mello, Edward G. (B), 1124 Garland St., Flint, Mich.
Pelton, Morton A. (B), 3625 Beaubien St., Detroit 1, Mich.
Scheffler, W. M. (C), 13577 Washburn Ave , Detroit 4, Mich.
Sitzman, Ray (B), 13367 Loretto St., Detroit 5, Mich.
Zanetti, Joseph R. (B), 15601 Woodland Dr., Dearborn, Mich.
Zucker, Myron (B), 1708 Crooks Rd., Royal Oak, Mich.

INDIANA

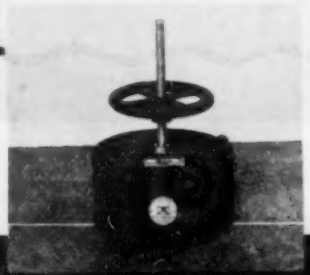
Baugh, Gordon A. (B), Hetherington & Berner Inc., 701 Ky. Ave., Indianapolis, Ind.
Haley, O. Ben (B), National Cylinder Gas Co., 909 N. Capitol Ave., Indianapolis, Ind.

WELDERS — SHIP FITTERS — PLATE FABRICATORS —

SPEED WELDING OPERATIONS
SAVE TIME, LABOR AND MATERIALS WITH
HERCO MAGNETIC ALIGNERS

Herco Aligners magnetically true-up and hold firmly in welding position, plates, beams, rods . . . eliminate time-consuming manual aligning, welding of temporary clamps, wedges or use of heavy weights to hold in position the parts to be welded. Hooked up to either AC or DC power, Herco Magnetic Aligners do the work normally required of a full man crew . . . in almost no time and with precise efficiency.

Herco Aligners are simple to operate, easy to handle and have a magnetic pull of 2,000 pounds per surface inch on one inch plate. Further details will gladly be sent on request.

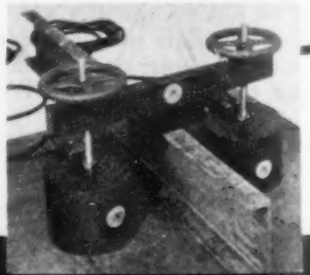


ALIGNING BUTT END PLATES FOR TACK WELDING

A Herco Aligner is placed squarely on the seam and when energized instantly draws both plates flush against the perfect surface of the magnet, thereby trueing up areas on both sides for tacking.

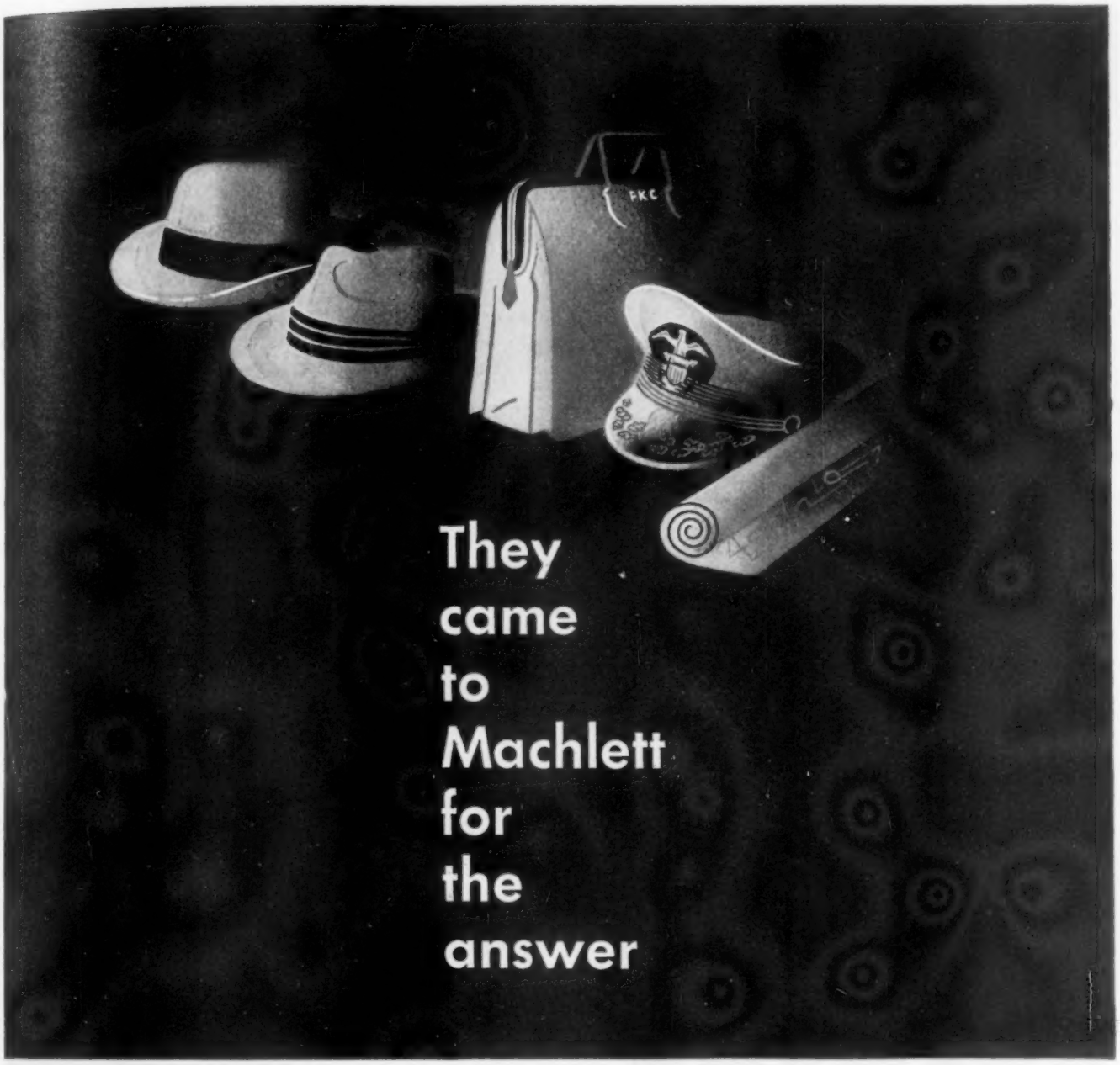
BUCKLING ELIMINATED BY PRESSURING STIFFENER BEAM

Shipbuilding requires reinforced stiffener beams across each plate at stated intervals. Warped plates are quickly positioned for welding to the stiffener beam by placing the aligner as illustrated.



HERCULES ELECTRIC & MFG. CO.
INCORPORATED
2416 ATLANTIC AVENUE ★ BROOKLYN 33, N. Y.

DC and AC WELDERS • TRANSFORMERS • MAGNETIC CLAMPS • SOLENOIDS • RIVET HEATERS
SPOT WELDERS • FLUORESCENT BALLASTS • SPECIAL CONTROLS

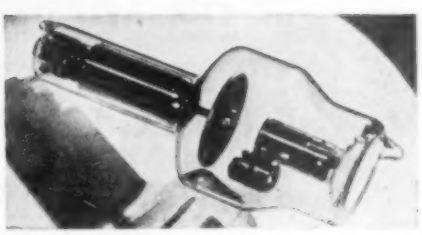


Some time ago a group of distinguished scientists and engineers designed, on paper, a most remarkable new instrument that could be invaluable in a certain war activity. But when the final calculations had been completed, it was realized that the device required a tube that not only had never been made, but perhaps never could be in adequate numbers.

An impressive delegation of these gentlemen visited the Machlett Laboratories, and explained the situation. Would we study the matter? "If you conclude the problem cannot be solved," they said in substance, "we shall have to revise our design and be satisfied with only a fraction of the desired performance, because we know that if a tube is too difficult for you, certainly no one in the world can make it."

This is the kind of challenge Machlett likes. Today that tube is produced in quantity and is serving our country at war.

Some day the full story of that extraordinary achievement can be told. Now it can only be referred to in general terms, as an example of the skill that makes Machlett the world's largest manufacturer of X-ray tubes for medical, dental and industrial uses. Today, Machlett, in addition, makes various electronic tubes for special purposes in those fields and in radio. Machlett does not make apparatus, but tubes only . . . Machlett Laboratories, Inc., Springdale, Connecticut.



Machlett x-ray tube with rotating anode. 100 kilovolts; 50 kilowatts.

MACHLETT

X RAY TUBES SINCE 1898

TODAY THEIR LARGEST MAKER

Renner, William D. (B), R. R. 1, Zionsville, Ind.
Shirley, Levi H (C), R. R. 1, Lebanon, Ind.

LEHIGH VALLEY

Rahn, Douglas A. (C), Westinghouse X-Ray Div., 522 Maple St., Allentown, Pa.

LOS ANGELES

Bassett, Floyd O. (B), 2034 Malcolm Ave., Los Angeles 25, Calif.
Bex, Joe C. (C), 4556 Weik Ave., Bell, Calif.
Cochran, John F. (B), 671 S. Woods Ave., Los Angeles 22, Calif.
Gasper, Louis W. (C), Western Pipe & Steel Co. of Calif., 5717 Santa Fe Ave., Los Angeles, Calif.
Harrison, W. D. (B), Quality Div., Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif.
Hereley, William, Jr. (C), 506 S. Bronson Ave., Los Angeles 5, Calif.
Knoles, Robert M. (C), 6316 Woodward Ave., Bell, Calif.
Martin, N. L. (B), 1834 E. 66th St., Los Angeles 1, Calif.
Mc Tigrit, John L. (B), 1415 Greenwood Ave., Apt. A, Torrance, Calif.
Noonan, Joseph T. (C), 2922—8th Ave., Los Angeles 16, Calif.
O'Neal, George B., Jr., (C), 1364 S. Pannes, Compton, Calif.
Pipher, Fred C. (C), 3727 W. 58th Pl., Los Angeles 43, Calif.
Powell, William T. (B), P.O. Box 2098, Terminal Annex, Los Angeles 54, Calif.
Trotter, C. E. (C), 10648 Esther Ave., Los Angeles 34, Calif.

LOUISIANA

Frank, F. M. (B), 1607 Gentilly Rd., New Orleans, La.
Holder, Jax T. (B), 205 Bank Ave., New Iberia, La.
Irving, George (B), Geo. Irving Machine & Iron Wks., 3426–30 Short St., New Orleans, La.

LOUISVILLE

Schneider, Leonard C. (C), 8129 Grant Line Rd., New Albany, Ind.

MARYLAND

Knapp, Harry C., Cpl. (B), Co. O, 2nd Regt., A. S. F. Tng. Center, Aberdeen Proving Grounds, Md.
Sanders, Kermit H. (C), R. D., Elysburg, Pa.

MILWAUKEE

Hille, Guenther H. (B), 2828A So. Pine Ave., Milwaukee 7, Wis.
Marshall, J. Keith (B), 5128 N. Idlewild Ave., Milwaukee, Wis.
Schaeffler, Anton L. (C), 2123B N. 46th St., Milwaukee 7, Wis.
Vredenburg, Arthur (C), 162 S. Hartwell Ave., Waukesha, Wis.

MOBILE

Babcock, Paul E. (B), 1514 Van Lee Circle, Mobile, Ala.

NEW JERSEY

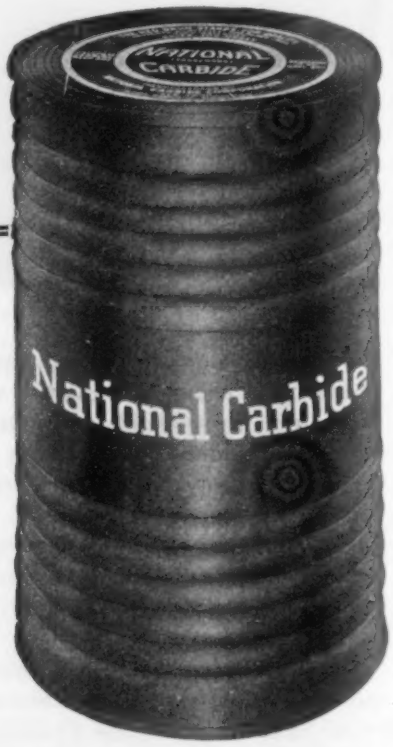
Briest, Clarence R. (B), 429 W. Hanover St., Trenton, N. J.
Captuto, Leo (C), Standard Welding Co., 313 Straight St., Paterson, N. J.
Dunbar, William B. (C), 362 Summer Ave., Newark, N. J.
Hood, Karl C. (B), 309 Ayliffe Ave., Westfield, N. J.
Miller, R. C. (C), 122 Clinton Ave., Newark, N. J.
Muller, Louis R. (B), Union Carbide & Carbon Corp., 646 Frelinghuysen Ave., Newark 5, N. J.
Pease, F. A. (C), F. A. Pease Labs., 11-13 Coes Pl., Newark, N. J.

NEW YORK

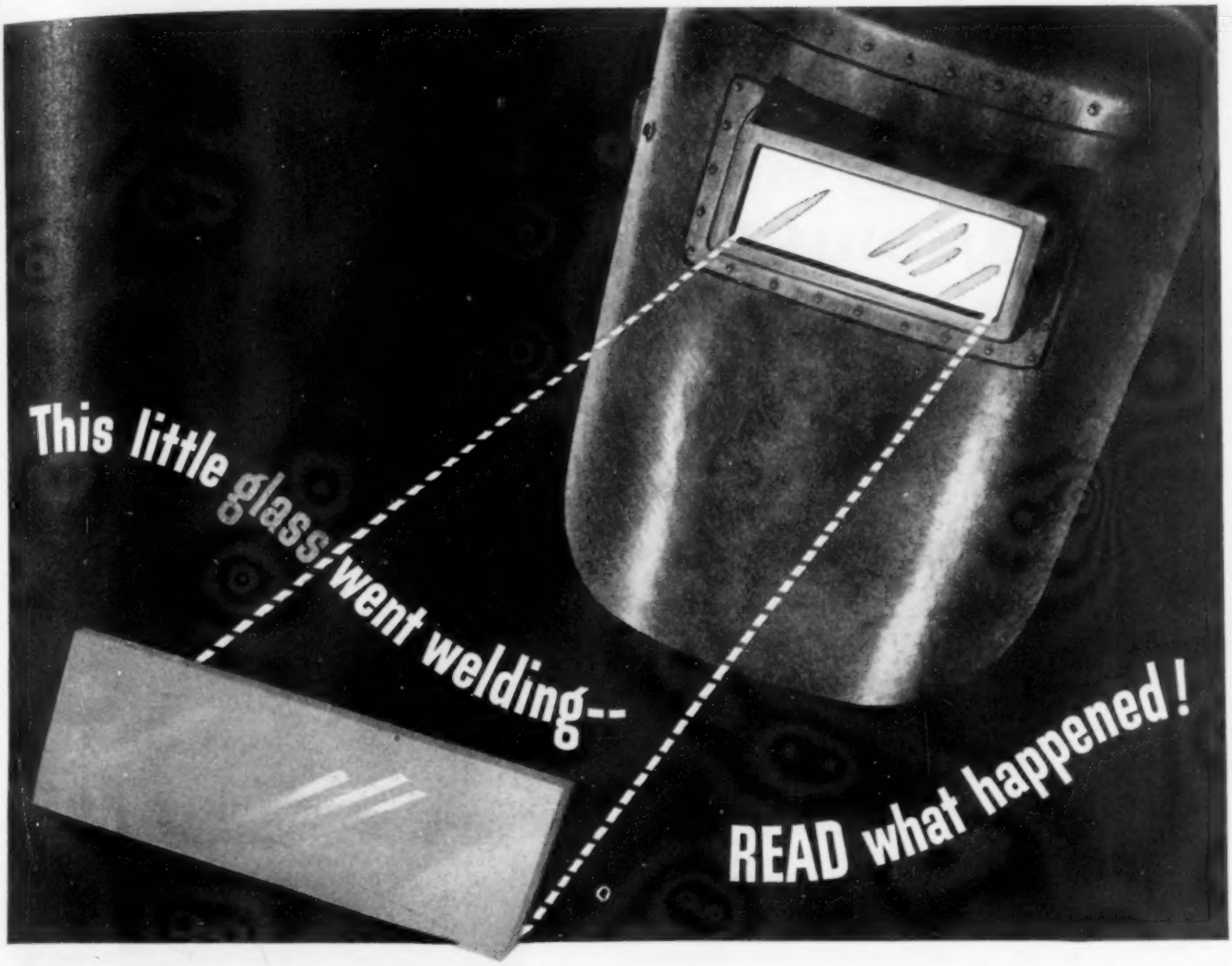
Lee, James (C), 61 Melrose Ave., Staten Island 1, N. Y.
Liessenberg, Henry (B), Combustion Engrg. Co., 200 Madison Ave., New York, N. Y.
Nowark, Robert W. (C), American Guarantee & Liab. Ins. Co., 80 John St., New York 7, N. Y.
Rice, Chester L. (B), 60 E. 42nd St, Room 950, New York 17, N. Y.

National
Carbide
IN THE RED DRUM

EFFICIENT
ECONOMICAL
DEPENDABLE



FOR WELDING and CUTTING
Use National Carbide in the Red Drum
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.



"Dalite" Splatterproof Cover Glasses save One shipyard 19,116 man-hours in one month!

A large shipyard enjoyed this saving when they switched from untreated welding-mask cover glasses to Bullock "Dalite" . . . the completely covered, processed glass with the tough, no-pit, no-peel, splatterproof baked-on coating that guards against heat breakage and damage from metal splatter.

Saving many minutes per worker per day, otherwise wasted in replacing broken or easily pitted glasses, "Dalite" gives real economy. Keeps more welders doing better welding . . . more of the time. If cost is counted as it should be, "Dalite" is actually cheaper! Welders tell us that one "Dalite" glass lasts as long as eight to fifteen ordinary glasses. *

Make this test at our expense. We'll send you several "Dalite" glasses . . . *free!* Test them side by side against your regular cover glasses. Put them under a steel-cutter's torch. Hold them there . . . right in the slag . . . see the difference! Write for your "Dalite" glasses, today.

FOR BURNER'S GOGGLES, TOO!

The same tough baked-on coating protects burner's goggles against heat breakage and damage from metal splatter. Available, as is the welding-mask type, in either blue or clear glass.

L. H. BULLOCK CO.

230 N. Michigan Ave., Chicago 1, Illinois
Detroit, Michigan Berkeley, California

NORTHERN NEW YORK

Cobean, Richard W. (C), General Elec. Co., Ind. Htg. & Welding Engrg. Div., Schenectady 5, N. Y.
Johnson, Ivar W. (C), 1141 Millington Rd., Schenectady 8, N. Y.
Lein, R. E. (C), 1588 Union St., Schenectady 8, N. Y.

NORTHWEST

Bauer, Donald (B), 1756 Grand Ave., Apt. 1, St. Paul 5, Minn.
Leonard, A. J. (C), 3331 Polk St., N. E. Minneapolis 13, Minn.
Menefee, C. E. (B), 2911—31st Ave., N.E., Minneapolis 13, Minn.
Morris, M. L. (C), 712½ Winter St., Superior, Wis.

OKLAHOMA CITY

Heidbreder, Warren, A/M (C), Barracks 78, N.A.T.T.C., Norman, Okla.

PEARL HARBOR

Curtis, E. R. (C), 907-A 10th Ave., Honolulu 32, T. H.
Gomeio, Frank (C), 1615 Martin St., Honolulu, T. H.
Richman, Sydney (C), 2606 Ave. U, Brooklyn 29, N. Y.
Todd, D. Charles (C), 2979 Kalakaua Ave., Honolulu, T. H.

PEORIA

Clark, Bernard F. (C), 1438 S. Jefferson, Peoria, Ill.
Kerivan, Thomas W. (C), Caterpillar Tractor Co., Peoria, Ill.
Markgraf, Frank F. (C), Box 85, Princeville, Ill.
McGarvey, H. R. (C), 423 Court St., Pekin, Ill.
Probasco, C. R. (C), Box 144, San Jose, Ill.

PHILADELPHIA

Duane, Nicholas (C), 919 Linden St., Wilmington 55, Del.
Franklin, Joseph N. (C), 5902 Addison St., Philadelphia 43, Pa.
Kunst, Joseph N. (C), Dravo Corp., P. O. Box 589, Wilmington 99, Del.

PITTSBURGH

Birmingham, George W. (B), R. D. 1, Groveton, Pa.
Gamberg, Edward R. (C), Westinghouse E. & M. Co., Research Labs., E. Pittsburgh, Pa.
Turnock, E. H. (B), 344 Woodside Rd., Pittsburgh 21, Pa.

PORTLAND, ME.

Bishop, Philip H. (C), 143 St. John St., Portland, Me.
Des Rosiers, Andrien T. (C), 148 Main St., Biddeford, Me.
Boivin, Leo J. (C), 52 Anderson St., Nestbrook, Me.
Dyer, Alfred V. (C), 67 Mount Fort St., Portland, Me.
Foote, Earle E. (C), 10 Lancaster St., Portland, Me.
Truman, Leon T. (C), R. F. D. 1, Oxford, Me.

PORTLAND, ORE.

Black, A. L. (B), 1305 S. E. Main St., Portland, Ore.
Brady, O. G. (C), Oregon Shipbldg. Corp., Portland, Ore.
Brown, Byron LaCamp (C), 8981 N. Fortune, Portland, Ore.
Carpani, Peter J. (C), 5133 N.E. 34th Ave., Portland, Ore.
Carter, J. (C), Box 199, Scappoose, Ore
Casey, E. L. (A), Commercial Iron Wks., Box 2230, Portland, Ore.
Chappell, Howard W. (C), 8835 N. Edison, Portland, Ore.
Childs, James (B), 20 N. W. 16th Ave., Portland 9, Ore.
Clements, A. C. (C), 5625 N. E. Cully, Portland 13, Ore.
DeGraff, R. M. (B), 3217 N. E. Brazee St., Portland 12, Ore.
Emert, O. S. (B), 935 N. Stafford, Portland 3, Ore.
Emery, Stephen E., Jr. (B), Rt. 1, Box 580, Beaverton, Ore.
Faville, Richard W. (B), 3625 N. E. Merges Dr., Portland, Ore.
Harrison, James R. (C), Box 13, Beaverton, Ore.
Karnis, John (B), American Bureau of Shipping, 722 Board of Trade Bldg., Portland 4, Ore.
Kirtland, Richard C. (B), R. 1, Scappoose, Ore.
Lambert, Frederick A. (B), R. 2, Box 782, Beaverton, Ore.
Parker, Ralph R. (C), 315 E. 20th, Portland, Ore.
Reiber, Alexander (C), 5135 N. E. 15th Ave., Portland, Ore.
Russell, Verle W. (B), Box 52, Scappoose, Ore.
Shanahan, Vincent J. (B), 5110 G. E. 12th, McLaughlin Hts., Vancouver, Wash.
Taylor, Laurence T. (B), 3256 N. E. Everett St., Portland, Ore.
Wallace, Gerald B. (B), Commercial Iron Wks., Ft. of S. W. Gibbs St., Portland, Ore.
Williams, Theodore R. (B), 4642 N. E. 32nd Pl., Portland 11, Ore.

SAN FRANCISCO

Epperson, Richard C. (B), 541 Alcatraz Ave., Oakland, Calif.
Fine, Louis J. (B), 115 Dorchester Ave., San Leandro, Calif.
Mattos, Walter (B), 1094—63rd St., Oakland, Calif.
Sanders, Paul W. (B), 84—7th Ave., San Francisco, Calif.

SYRACUSE

Shea, Dan (C), Dan Shea Distributors, 204 Maplehurst Ave., Syracuse, N. Y.
Suniewick, Stanley (B), 108 Loehr Ave., Syracuse, N. Y.

TIDEWATER

Allsbrook, Jack Dewey (B), 127 North St., Suffolk, Va.
Brown, Jesse A. (B), 3606 Margaret Ave., Kingman Heights, Portsmouth, Va.
Brown, John (B), 4931 Devonshire Rd., Norfolk, Va.
Butler, Allen M. (B), 301 Dinwiddie St., Portsmouth, Va.
Duffy, Patrick C. (C), 13 Chatham Rd., Loxley Pl., Portsmouth, Va.
Gardner, Willie C. (C), 89 Farragut St., Portsmouth, Va.
James, Ralph H. (B), 249 Florida Ave., Portsmouth, Va.
Powell, Thomas T. (B), 7 Fiske St., Portsmouth, Va.
Preslar, Roy E. (B), 504 Gygax Ave., Portsmouth, Va.
Smith, George G. (B), 44 Wallace Circle, Portsmouth, Va.
Sprouse, William D. (B), 201 Park Manor Rd., R. F. D. 1, Box 1000, Portsmouth, Va.
Stauffer, Harold A. (B), 320 Edwards St., Portsmouth, Va.
Stephens, Ruben C. (B), 21 Helm St., Portsmouth Va.
Stowe, John D. (B), 38 Afton Pkwy., Apt. 1, Portsmouth, Va.

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

NET MONTHLY ADVERTISING RATES

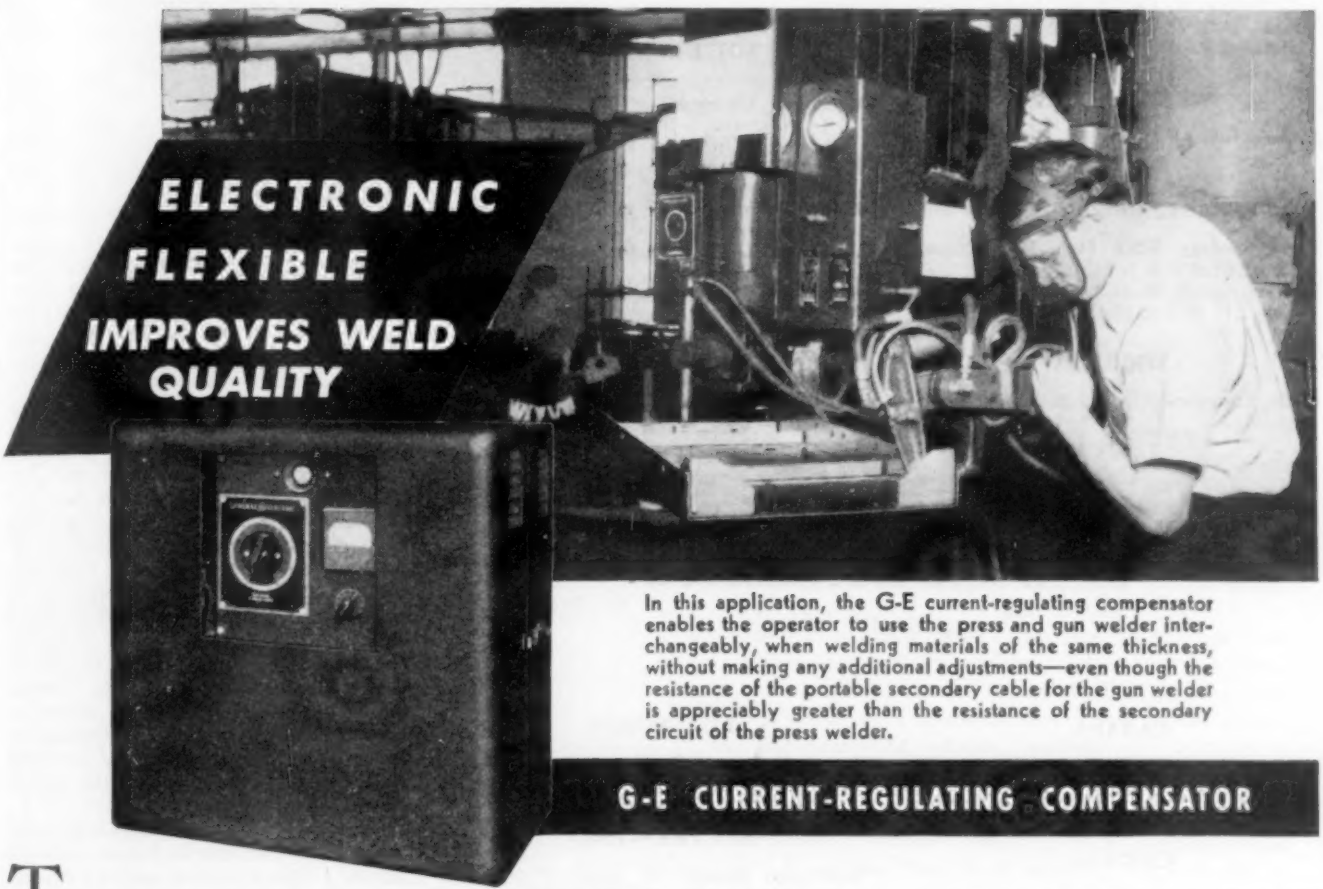
Black and White *Effective April 1943*

Space	One Insertion	Three Insertions	Six Insertions	Twelve Insertions
*Full Page	$120	$105	$95	$85
Half Page	70	60	55	50
Quarter Page	42	38	35	30
Eighth Page	30	25	20	18
*Inside Preferred	135	120	110	100

*10% Extra for bleed full pages. Color $40 Extra per color added.

SPOT WELDING? SEAM WELDING?

Here's a NEW Method of Keeping Weld Current Constant . . . AUTOMATICALLY



In this application, the G-E current-regulating compensator enables the operator to use the press and gun welder interchangeably, when welding materials of the same thickness, without making any additional adjustments—even though the resistance of the portable secondary cable for the gun welder is appreciably greater than the resistance of the secondary circuit of the press welder.

G-E CURRENT-REGULATING COMPENSATOR

THIS new current-regulating compensator will *automatically* correct for line-voltage variations and power factor, or impedance, changes, and will do it within three cycles. It will hold the current within plus or minus 2 per cent of normal, where changes would cause the unregulated current to vary as much as plus or minus 20 per cent.

You Get These 5 Other Advantages, Too

1. *Flexibility of Operation*—The same control settings can be used, and consistent results can be obtained when: (a) using a press-type spot welder; (b) using a gun welder connected to the same welding transformer; or (c) welding magnetic materials with a press- or gun-type welder with the material in or out of the throat of the welding machine.

2. *Improved Quality*—Without the use of this control, the introduction of material in the throat of the welder would cause unsatisfactory welds because of the changes in welding current. It would do so in many applications, such as in the welding of barrels, propeller blades, or large steel assemblies.

3. *Seldom Needs Adjustment*—After the operator has once determined the proper settings for an operation, no further adjustments are necessary—the current-regulating compensator takes care of variations.

4. *Electronic*—Electronic tubes and circuits insure fast operation, good results, long service, low maintenance.

5. *Correlated Design*—This current-regulating compensator is designed for use only with G-E resistance-welding controls which include heat control by the phase-shift method. Complete interconnection diagrams are supplied to assist in installing this equipment.

Want More Information?

Bulletin GEA-4220, well-illustrated, describes all the features that make this new current-regulating compensator the solution of many resistance-welding problems. Ask our local office for a copy today. *General Electric Company, Schenectady 5, N. Y.*

Buy all the BONDS you can—
and keep all you buy

GENERAL ELECTRIC

645-30-8960

RESISTANCE-WELDING CONTROL

TOLEDO

Bersticker, Lloyd (C), 4234 Templer Rd., Toledo 12, Ohio.
Gustafson, Paul J. (B), 840 Woodland Ave., Toledo 7, Ohio.
Smith, Harold A. (B), 936 Vance St., Toledo, Ohio.

WASHINGTON, D. C.

Moody, Chas. G. (B), 3031 Tennyson St., N. W., Washington, D. C.
Rose, Wm. R., Jr. (C), 1441—19th St., N. Arlington, Va.
Snider, Janie D. (C), 8202 Wisconsin Ave., Bethesda, Md.

WESTERN MASS.

Sloan, John F. (C), 96 Brandon Rd., Worcester, Mass.

WESTERN NEW YORK

Cady, George Fitch (B), 101 Niagara Blvd., Fort Erie N., Ont., Canada.
Keeney, James M. (C), c/o Buffalo Tank Corp., P. O. Box 16, Buffalo 5, N. Y.

WICHITA

Crole, Laurence (C), 331 N. Senna, Wichita, Kan.
Houchin, Gilbert E. (B), 550 N. Grove, Wichita, Kan.
Krasser, Earl (C), 544 S. Hillside Ave., Wichita 9, Kan.
Matz, Jos. B. (B), Coleman Lamp & Stove Co., 250 N. St. Francis, Wichita 1, Kan.
Radford, Jack T. (C), 2306 E. Harry, Wichita, Kan.
Sanders, L. M. (B), 1020 S. Hydraulic, Wichita, Kan.
Summers, Roy L. (B), 740 Ellis, Apt. 3, Wichita, Kan.

NOT IN SECTIONS

Gallagher, Charles (B), Engrg. Supply Co. of Australia, Box 1411T, G.P.O., Brisbane, Queensland, Australia.
Hayes, Elliott A. (C), 35C Carolina Ave., Navy Yard 51, S. C.
Hauge, Konrad I. (B), 1115 Marion Ave., Nashville 6, Tenn.
Myhr, A. I. (B), Nashville Bridge Co., Nashville 1, Tenn.
Pandolfino, Guy R. (C), 343 E. Bald Eagle St., Lock Haven, Pa.
Revell, Erle T. (C), P. O. Box 1092, Columbus, Ga.
Sherburn, Cloyd B. (B), Economy Shop, 812 W. Main St., N. Manchester, Ind.
Vold, John (B), Vold Shops, Platte, S. D.

Members Reclassified

During Month of April

CANADA

Sondenaa, Jens V. (from D to C), Royal Norwegian Air Force, 341 Church St., Toronto, Canada.

CHICAGO

Jensen, Arnold C. (from D to C), 8445 Luella Ave., Chicago, Ill.
Tonge, Maxwell (from D to C), 2152 W. Division St., Chicago, Ill.

INDIANA

Hexamer, George B. (from D to C), 1533 Noble St., Anderson, Ind.

NEW JERSEY

Caroselli, Dominick (from D to C), 345 Newark Ave., Jersey City, N. J.

NEW YORK

Gothinger, Chas. (from D to C), Arma Corp., 254—36th St., Brooklyn, N. Y.
Sheridan, Wm. A. (from D to C), 442 Stirling Pl., Brooklyn, N. Y.

NORTHWEST

Nelson, W. Roland (from D to C), 1678 Hartford Ave., St. Paul, Minn.

PHILADELPHIA

Krieg, Joseph A. (from D to C), 504 Holmes Rd., Ridley Farms, Morton, Pa.

PITTSBURGH

Campbell, George C. (from D to C), R. D. 3, Coraopolis, Pa.

SAN FRANCISCO

Alexander, George W. (from D to C) 108 Daniels Ave., Vallejo, Calif.
Cole, Everett H. (from D to C), 1808 Octavia St., San Francisco, Calif.
Markman, Frederick P. (from D to C), 4424 Camden St., Oakland, Calif.

WESTERN NEW YORK

Goodford, Leon (from D to C), 81 Progressive Ave., Buffalo, N. Y.

WASHINGTON, D. C.

Alleman, Cyrus Earl, Jr. (from D to C), Metalsmith 1st Class, Experimental Diving Unit, Navy Yard, Washington, D. C.

WICHITA

Burrows, Delmer (from D to C), 104 E. Osage, Paola, Kan.

NOT IN SECTIONS

Adams, Paris (from C to B), Adams Welding Shop, P. O. Box 85, Spurgeon, Ind.
Clouse, Ben T. (from D to C), 431 E. Wayne St., Ft. Wayne, Ind.
Hudson, Sherman (from D to C), Walker, Iowa.

POSTWAR USE OF LIGHT METALS, ESPECIALLY ALUMINUM ALLOYS

Pittsburgh, Pa., June 19.—Increased postwar use of light metals, especially aluminum alloys, with resultant economies, was forecast in a paper given tonight at the semi-annual meeting of the American Society of Mechanical Engineers, by E. C. Hartmann, G. O. Hoglund and M. A. Miller, of the Aluminum Company of America, Pittsburgh. In a paper entitled "Methods of Joining Aluminum Alloy Products," it was stated that:

"American industry has never fully realized the economies that can be achieved through the use of the light metals, particularly the aluminum alloys. Most of the reasons for this are no longer valid. The end of the war will find fabricating capacity to meet the most ambitious programs that can be foreseen. Methods of joining will become increasingly important as the uses of aluminum alloys expand. Many procedures are available for making joints in aluminum alloy products—riveting, welding, brazing, soldering and resin bonding.

"There are five aluminum alloys used commercially for rivets. All of the welding methods, gas, arc, and resistance welding, are used with the aluminum alloys. Gas and arc welding are not ordinarily used with the highest strength heat-treated alloys because the heat of welding tends to anneal the metal adjacent to the weld, thus markedly reducing the properties locally. In certain welded structures, however, reheat treatment after welding can be used to restore strength in welded high strength alloys. Successful spot welding of aluminum alloys, usually requiring different equipment from ferrous materials, has been widely used, especially in the manufacture of airplanes.

"Brazing of aluminum alloys is generally cheaper than welding and gives excellent results. Furnace, torch, and dip brazing are used. Soldering is perhaps the least known joining method for aluminum alloys. Most of the obstacles to this method of joining have been overcome, and the process is now commercial in several important aluminum alloys. Resistance to corrosion is often critical, so that protective measures must be taken.

"Resin bonding consists of cementing two surfaces together with any one of a group of organic materials which exhibit proper bonding properties. The ultimate possibilities of this method of joining aluminum alloy parts appear to be very attractive."

Annual Meeting
American Welding Society
Oct. 16-19
Hotel Cleveland
Cleveland, Ohio
Plan to attend

The EUTECTIC Welder
MARCH 1944
TOUGH CAST IRON WELDING PROBLEMS SOLVED
NEW WELDING HORIZONS
New Process
Reasons for Cast Iron Welding "Headaches"
For Great Strength Oxy-Acetylene Application Is Recommended

Announcing A NEW WELDING PUBLICATION

For
WELDERS • ENGINEERS

. . . Created to disseminate factual information and knowledge gained from the experience of successful users of EUTECTIC *Low Temperature* Welding, the new welding process which is gaining wide acceptance in production, salvage and maintenance. All metals from aluminum to zinc die-castings can be joined by this process. Applicable with oxy-acetylene torch, metallic-arc, induction and furnace heating.

The EUTECTIC WELDER is prepared by the engineering and research staff of The Eutectic Welding Alloys Company, and supplemented by contributions from users of the process in all fields.

Welders, welding engineers, and metallurgists have acclaimed the arrival of The EUTECTIC WELDER. An engineer writes:

"Found your publication a real boon to our welding department. Please add the following names to your list and make sure to send us current issues every month."

These Features Each Month

★ **Welding Metallurgy**

★ **Cost Analysis**

★ **Welding Design**

★ **Production Ideas**

★ **Salvaging Tools**

★ **New Maintenance Economies**

★ **Useful Tricks and Tools**

GET IT FREE — Mail Coupon Today

EUTECTIC WELDING ALLOYS COMPANY Dept. E-7
40 Worth St., New York 13, N. Y.

Please send me The EUTECTIC WELDER every month.

Name_____

Company_____ Position_____

Address_____ City_____

Eutectic Welding

EUTECTIC®
***LOW TEMPERATURE*® WELDING**

EUTECTIC WELDING ALLOYS COMPANY 40 Worth St., N. Y.
Originators of the Low Temperature Welding Process
®Reg. U. S. Pat. Off.

TENTATIVE PROGRAM

TWENTY-FIFTH ANNUAL MEETING AMERICAN WELDING SOCIETY OCTOBER 16–19, 1944

HOTEL CLEVELAND, CLEVELAND, OHIO

MONDAY, OCTOBER 16th, Morning—9:30 A.M.

OPENING SESSION

Chairman—DAVID ARNOTT
President, American Welding Society

Vice-Chairman—E. V. DAVID
Chairman, Convention Committee

PRESENTATION OF MEDALS AND PRIZES

WELDING AIDS THE WAR EFFORT

Welding as an Aid in Shipbuilding Construction, by ADMIRAL H. L. VICKERY, U. S. Maritime Commission

Welding as an Aid in the Fabrication of Ordnance Equipment, by COL. S. B. RITCHIE, Office, Chief of Ordnance

Welding in Aircraft Construction, by W. B. STOUT, Consolidated Vultee Aircraft Corp.

* Acceptance not yet received.

Monday Afternoon—2:00 P.M.

THREE SIMULTANEOUS SESSIONS

WELDING AND CUTTING IN HEAVY INDUSTRIES

Chairman—R. J. YARROW,
Republic Structural Iron Works

Vice-Chairman—J. M. DRISCOLL,
Air Reduction Sales Co.

Heavy Oxyacetylene Cutting
by G. L. WALKER and H. G. HUGHEY, Air Reduction Sales Co.

Steel Mill Maintenance
by E. W. GRUBER, Wheeling Steel Corp.

Unusual Applications of Gas Cutting in Ordnance Fabrication
by C. M. UNDERWOOD, Northern Ordnance, Inc.

RAILROAD AND TRANSPORTATION

Chairman—J. W. SHEFFER,
American Car and Foundry Co.

Vice-Chairman—A. G. OEHLER,
Associate Editor, Railway Age

Welding of Aluminum Tank Cars
by A. H. WOOLLEN, Railroad Sales, Aluminum Co. of America

Railroad Maintenance Welding
by CLAY W. ROBERTS, The Pennsylvania Railroad

WELDABILITY

Chairman—A. B. KINZEL,
Union Carbide & Carbon Corp.

Vice-Chairman—C. H. JENNINGS,
Westinghouse Electric & Mfg. Co.

Discussion Weldability of Manganese Steel
by W. B. BROOKS, Cramp Shipbuilding Co.

High Tensile Manganese Silicon Steels for Welded Fabrication
by G. G. LUTHER and F. H. LAXAR, Naval Research Lab.

The Bead-Weld Nick-Bend Test for Ductility
by C. E. JACKSON and G. G. LUTHER, Naval Research Lab.

The Influence of Minor Variables of Weldability
by R. D. STOUT, S. S. TÖR and G. E. DOAN, Lehigh University

Monday Evening—8:00 P.M.

ADAMS' LECTURE

Chairman—WENDELL F. HESS,
Rensselaer Polytechnic Institute

Vice-Chairman—R. H. ABORN,
United States Steel Corp.

C. A. Adams' Lecture, by DR. A. B. KINZEL, Union Carbide and Carbon Corp.

Experience has proved that Unamatic Welding can be used advantageously:

1. Wherever the work can be passed under a given point, known as the point of the arc.
2. Wherever the head, when mounted on a suitable fixture or travel carriage, can travel along the weld line.

Three types of welding are available with Unamatic equipment: (a) light-coated wire, (b) shielded-arc wire, (c) wire and flux for submerged-arc.

Investigate this *complete* automatic arc welding service. One of our field engineers will be glad to call and give you complete information . . . no obligation, of course.

UNAMATIC for FASTER • BETTER LOWER COST ARC WELDING!

CONTROLLED QUALITY **UNAMATIC WELDING** CONTINUOUS PRODUCTION

UNA WELDING INC. • 1615 COLLAMER AVE. • CLEVELAND 10, OHIO

TUESDAY, OCTOBER 17th, Morning—9:30 A.M.

THREE SIMULTANEOUS SESSIONS

RESISTANCE WELDING

Chairman—L. C. BIBBER, Carnegie Illinois Steel Corp.

Vice-Chairman—G. N. SIEGER, S.M.S. Corp.

Spot Welding Machines for Heavy Gauges of Ferrous and Non-Ferrous Metals
by MARIO SCIAKY, Sciaky Bros.

Heat Transfer Across Contact Surfaces
by W. B. KOUWENHOVEN, Dean, School of Engineering, Johns Hopkins University

Roll Spot Welding
by B. L. WISE, Federal Machine and Welder Co.

Problems in Spot Welding Heavy Mild Steel Plate
by F. R. HENSEL, E. I. LARSEN and E. F. HOLT, P. R. Mallory & Co., Inc.

RESEARCH

Chairman—H. C. BOARDMAN, Chicago Bridge & Iron Co.

Vice-Chairman—R. E. KINKEAD, Consulting Welding Engineer

The Effect of Postheating in Welding Medium Alloy Steels
by M. A. PUGACZ and G. J. SIEGEL Naval Research Laboratory

Stress Relieving Study
by PROF. J. R. STITT, Ohio State University

The Effects of Metallurgical Changes Due to Heat Treatment Upon the Fatigue Strength of Carbon-Steel Plates
by W. H. BRUCKNER, and W. H. MUNSE, University of Illinois

STRUCTURAL

Chairman—A. S. LOW, The Austin Co.

Vice-Chairman—J. F. MAINE, Republic Structural Iron Works

Standard Details for Welded Building Construction
by H. W. LAWSON, Bethlehem Steel Co.

Field Welded Pressure and Variable Volume Storage Tanks
by FRED L. PLUMMER, Hammond Iron Works

Tuesday Afternoon—2:00 P.M.

THREE SIMULTANEOUS SESSIONS

RESISTANCE WELDING

Chairman—R. E. POWELL, Western Electric Co.

Vice-Chairman—H. C. COGAN, National Electric Welding Machines Co.

Low Reactance Cable for Resistance Welders
by MYRON ZUCKER, Mackworth G. Rees, Inc.

The Flash Welding of Alloy Steels—Welding Techniques and Variables
by J. J. RILEY, **Metallurgical and Physical Characteristics,** by J. C. Barrett, Taylor-Winfield Corp.

Small Portable Condenser Welding Set
by E. M. CALLENDER, E. G. Budd Mfg. Co.

RESEARCH

Chairman—S. L. HOYT, Battelle Memorial Institute

Vice-Chairman—G. V. SLOTTMAN, Air Reduction Sales Co.

Some Recent Developments in Stainless Steel Welding
by D. L. MATHIAS, Metal & Thermit Corp.

Bi-axial Fatigue Strength of Low-Carbon Steels
by GEORGE K. MORIKAWA and LeVAN GRIFFIS, Illinois Institute of Technology

Intergranular Corrosion of Stainless Steel Welds
by WM. T. TIFFIN, University of Oklahoma

Correlating Weldability and Jominy Hardness
by HOWARD SIMS, Black, Sivalls and Bryson, Inc.

SHIPS

Chairman—J. L. WILSON, American Bureau of Shipping

Vice-Chairman—S. A. MIDNIGHT, American Ship Building Co.

Welding in Ship Construction
by DAVID ARNOTT, American Bureau of Shipping

Technical Control of Welding in Ship Construction
by M. H. MacKUSICK, California Shipbuilding Corp.

Welding in Ship Construction
by M. N. MALTSEFF, Western Pipe and Steel Co.

Multiple and Stack Machine Cutting
by A. H. YOCH, Air Reduction Sales Co.

Tuesday Evening—8:00 P.M.

UNIVERSITY RESEARCH CONFERENCE

WEDNESDAY, OCTOBER 18th, Morning—9:30 A.M.

TWO SIMULTANEOUS SESSIONS

AIRCRAFT

Chairman—G. S. MIKHALAPOV, National Research Council

Vice-Chairman—MR. DODGE, Sciaky Bros.

Aircraft Welding
by H. O. KLINKE, Republic Aviation Corp.

Helium Shielded Arc Welding of Stainless Steel Exhaust Collectors
by FRANCIS H. STEVENSON, Lockheed Aircraft Corp.

Multi-Arc Welding of Aluminum Alloys
by M. R. RIVENBURGH and C. W. STEWARD, Curtiss-Wright Corp.

Arc Welding in Aircraft
by H. E. SHAY, Douglas Aircraft Co., Inc.

RESEARCH

Chairman—ISAAC HARTER, Babcock & Wilcox Co.

Vice-Chairman—E. R. SEABLOOM, Crane Co.

Weldability-as-Rolled vs. Heat-Treat High Strength Constructional Steels
by LT. S. A. HERRES and W. L. WARNER, Watertown Arsenal

Stress Relief of Welded Joints
by PAUL C. CUNNICK, Lt. Col. Ordnance Dept., Rock Island Arsenal

Weldability Tests of Cast Steel
by C. E. JACKSON and F. S. McKENNA, Naval Research Lab.

Development and Application of Modern Heavy Coated Arc Welding Electrodes
by D. C. SMITH and W. G. RINEHART, Harnischfeger Corp.

Here's a great small spotwelder that is

★ *sturdy...*

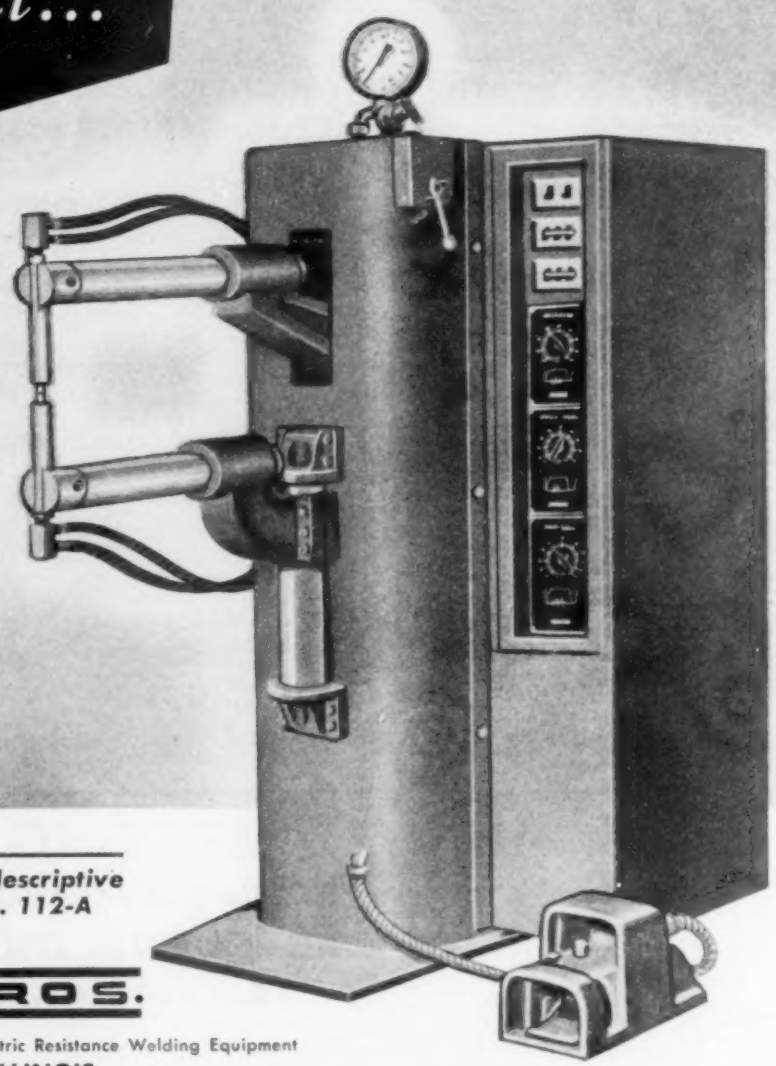
★ *precise...*

★ *fast...*

★ *compact...*

SCIAKY engineering has proved that it is possible to make a machine that is small, yet capable of delivering fast, high quality spot welds in day in and out production. Incorporated in this rocker arm type welder are exclusive features hitherto only used in larger machines. The use of heavy duty roller bearings at the fulcrum point of the arm, together with a special rubber cushion in the pressure cylinder, assure smooth action . . . eliminate hammering and wear. The design is compact with controls and contactor in a hinged cabinet . . . dials are convenient to operator and unit may be easily installed or moved.

If your problem involves the fabrication of mild, stainless or zinc-coated steels and brass in light gauges, it will pay you to consider the "PMCR.0-1."



MODEL PMCR.0-1

Rated 30 KVA at 50% duty cycle for power supply of 440 or 220 volts, 60, 50 or 25 cycles. Capacity: clean mild steel from two thicknesses of .016" up to and including .080"—stainless steel up to a maximum of .040" plus .040". Speed on two thicknesses of .032" thick pickled mild steel is 180 welds per minute. Maximum electrode pressure at 24" throat depth is 1000 lbs.

Write for descriptive bulletin No. 112-A

SCIAKY BROS.

Manufacturers of a Complete Line of AC and DC Electric Resistance Welding Equipment

4915 W. 67TH ST., CHICAGO, 38, ILLINOIS

In England: Sciaky Electric Welding Machines, Ltd., London

Branch offices in Detroit and Los Angeles

Wednesday Afternoon—2:00 P.M.

THREE SIMULTANEOUS SESSIONS

AIRCRAFT

Chairman—G. O. HOGLUND, Aluminum Co. of America
Vice-Chairman—E. S. JENKINS, Curtiss-Wright Research Lab.

The Geometry of the Spot Welding Tip and Its Relation to Tip Life
by E. D. CRAWFORD and C. W. STEWARD, Curtiss-Wright Corp.

Survey of Cleaning Practices for Spot Welding Aluminum Alloys
by F. M. MORRIS, Kaiser Cargo, Inc., Fleetwings Div.

An Evaluation of Process Control of Aircraft Welding
by P. H. MERRIMAN, The Glenn L. Martin Co.

Gas Shielded Arc Welding
by F. A. WASSELL, General Electric Co.

MACHINERY

Chairman—A. E. GIBSON, Wellman Engineering Co.
Vice-Chairman—R. J. KRIZ, The James H. Herron Co.

Production Problems and Production Control
by E. C. BREKELBAUM, Harnischfeger Corp.

Routine Inspection and Salvage of Machinery Weldments — Rough, Partially Machined and Machined
by JAMES W. OWENS, Fairbanks, Morse & Co.

Welded Jigs and Fixtures
by A. N. KUGLER, Air Reduction Sales Co.

Design of Welded Machinery
by JOHN MIKULAK, Electric Machinery Manufacturing Co.

PIPING AND PRESSURE VESSELS

Chairman—A. C. WEIGEL, Combustion Engineering Co.
Vice-Chairman—R. W. EMERSON, Pittsburgh Piping & Equipment Co.

Pressure Vessel Welding
by EDWARD B. McGUIRE, Hamler Boiler & Tank Co.

Effect of Normalizing on Welded Carbon-Molybdenum Pipe
by D. H. COREY, The Detroit Edison Co.

Properties of Welded Joints Between Dissimilar Metals
by E. C. CHAPMAN and R. E. LORENTZ, Combustion Engineering Co.

Welding of Layer Vessels
by H. H. NEEDHAM, A. O. Smith Corp.

Wednesday Evening—6:30 P.M.

Section Officers Dinner and Conference

THURSDAY, OCTOBER 19th, Morning—9:30 A.M.

TWO SIMULTANEOUS SESSIONS

FOUNDRY

Chairman—L. A. DANSE, Cadillac Motor Car Div.
Vice-Chairman—AUSTEN J. SMITH The Lunkenheimer Co.

Oxyacetylene and Arc Welding Practices in Steel Foundries
by FRANK KIPER and LAWRENCE GABES, Ohio Steel Foundry

Machine Cutting of Risers, Flame Scarfing to Remove Padding, and Flame Gouging to Remove Webs and Defects
by G. E. BELLEW, Air Reduction Sales Co.

Repair of Castings
by L. A. DANSE, Cadillac Motor Car Div., General Motors Corp.

MISCELLANEOUS

Chairman—W. E. CRAWFORD, A. O. Smith Corp.
Vice-Chairman—A. L. PFEIL, Universal Power Corp.

Joining at Low Temperatures
by W. D. WASSERMAN, Eutectic Welding Alloys Co.

Developments in Metallizing
by WM. C. REID, Metallizing Engineering Co.

Ordnance Specifications in Welding
by CAPT. J. F. RANDALL, Office of Chief of Ordnance, War Department

---

Thursday Afternoon—2:00 P.M.

Business Meeting

3:00 P.M.

Board of Directors Meeting

ANNUAL MEETING, A. W. S.

HOTEL CLEVELAND

CLEVELAND, OHIO

Make Reservations Early

Write to
Housing Committee,
National Metal Congress,
1604 Terminal Tower Bldg.,
Cleveland 13, Ohio

Mention American Welding Society